AD NUMBER
AD022349
CLASSIFICATION CHANGES
TO: unclassified
FROM: confidential
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; SEP 1953. Other requests shall be referred to Aberdeen Proving Ground, MD.
AUTHORITY
30 Sep 1965, DoDD 5200.10; APG D/A ltr, 4 Jan 1974

AD _____

CONFIDENTIAL

Aberdeen Proving Ground

MARYLAND SECURITY INFORMATION

DEVELOPMENT AND PROOF SERVICES

Report OCO Project No.

ARMY CS ABERDEEN PROVING GROUND MD 115

DESIGN AND FABRICATE A HIGH-VELOCITY CALIBER .22 CARTRIDGE, MODIFY A STANDARD M2 CARBINE TO FIRE THE CARTRIDGE, AND EVALUATE THE WEAPON-AMMUNITION COMBINATION

TWENTY-FIFTH REPORT ON PROJECT TS1-2

53AA-19446

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

Authority: TT ORD 12153
2 June '53

Priority:

GAGustafson/vr
29 September 1953

DESIGN AND FABRICATE A HIGH-VELOCITY CALIBER .22 CARTRIDGE, MODIFY A STANDARD M2 CARBINE TO FIRE THE CARTRIDGE, AND EVALUATE THE WEAPON-AMMUNITION COMBINATION

TWENTY-FIFTH REPORT ON PROJECT TS1-2

DATES OF PROGRAM: 13 November 1952 to 21 August 1953

OBJECT

The purpose of the program is to increase the effectiveness of the M2 carbine, in both semi- and full-automatic fire, by adapting it to a high-velocity, small-caliber cartridge.

SUMMARY

A cartridge was designed in caliber .22 with an overall length to permit use in standard carbines and magazines. Velocity, pressure, and accuracy barrels were fabricated, and ammunition dies were constructed. A caliber .30, M2, carbine was modified to fire the caliber .22 cartridge, and it was fitted with a compensator and bipod. Lead-core, jacketed bullets were obtained from commercial production, and armor-piercing bullets were made by inserting hardened steel cores in the commercial-type bullets. The cartridge and the weapon-ammunition combination were evaluated and compared with the performance of the standard, caliber .30, M2 carbine and its ammunition and, in the case of qualification firing, with the M1 rifle.

CONCLUSION

It is concluded that the caliber .22 carbine is superior to the standard caliber .30 M2 model in that it gave markedly better performance with respect to velocity, trajectory, penetration, and accuracy in both semi- and full-automatic fire.

RECOMMENDATION

It is recommended that five caliber .22 carbines and 20,000 rounds of ammunition be procured and tested at Aberdeen Proving Ground, in the presence of members from Army Field Forces Board No. 3, to learn if ammunition of this type offers any military advantages over that now employed in carbines, rifles or submachine guns.

DISTRIBUTION FOR TWENTY-FIFTH REPORT ON PROJECT TS1-2

Chief of Ordnance Washington 25, D. C. Attn: ORDTS ORDTX-AR	 3 copies 1 copy
Commanding Officer Small Arms Ammunition Center 4300 Goodfellow Boulevard St. Louis 20, Missouri	1 copy
Commanding Officer Frankford Arsenal Philadelphia 37, Pa.	1 copy
AFF Liaison Officer Aberdeen Proving Ground, Md. Attn: Colonel Lewis Thru: Technical Information Branch Aberdeen Proving Ground, Md.	 1 copy
Technical Information Branch Aberdeen Proving Ground, Maryland	1 copy
Technical Information Branch Aberdeen Proving Ground, Maryland	Original

I INTRODUCTION

A. DISCUSSION

1. In April, 1952, Mr. T. F. Colleran, Director of Development and Proof Services, and Colonel J. D. Armitage, Chief of Arms and Ammunition Division at Aberdeen Proving Ground, granted verbal approval to a project proposed by the Small Arms and Aircraft Weapons Branch to investigate the merit of small-caliber, high-velocity cartridges for use in rifles and carbines. Colonel R. R. Studler, Office Chief of Ordnance, ORDTS, also gave oral approval to the preliminary investigation with the understanding that a program would be authorized by his office if the cartridges proved promising in early tests. This report covers the test of the carbine and carbine-ammunition phase of the program.

2. Considerable delay was encountered in obtaining suitable barrel blanks and chambering reamer stock for making velocity and pressure barrels. In November, 1952, sketches of "Maximum Cartridge" and "Minimum Chamber" were made and the project was initiated in the Small Arms Branch gunsmith shop on a spare-time basis because of its low priority.

3. The caliber .30 carbine has been regarded with considerable disfavor during the recent fighting in Korea, probably to some extent because it has been employed tactically as a rifle rather than as a replacement for the pistol. Perhaps this general misuse of the carbine indicates that there is a real combat requirement for a weapon of the carbine type. Battlefield reports indicate that poor functioning, accuracy and stopping power were charged against this weapon.

4. It was thought at this station that the complaints against the carbine could be eliminated, in the most part, by furnishing a cartridge of high velocity, with resulting flat trajectory, and good accuracy to afford a high percentage of hits on a man-size target up to 300 yards. Past experience with privately owned light-weight, sporting rifles of small caliber and high velocity indicated that the 300-yard criterion for effective range could probably be met with respect to accuracy and trajectory, and that a good chance for improving terminal performance over that of the caliber .30 carbine cartridge existed. It is believed that a large portion of malfunctions charged against the weapon in the field were caused by the recognized poor performance of 30-round magazines and to unsatisfactory cold-weather lubricants in use during the early stages of the Korean conflict.

5. By using 15-round magazines and proper maintenance, with emphasis on proper lubrication in cold weather, the performance of the carbine might be placed at a satisfactory level. By employing a high-velocity cartridge, the complaints against the ineffectives of the cartridge might be eliminated.

6. The poor reputation of the light-weight carbine for burst-fire dispersion is well deserved. The relatively heavy bullet develops rather severe recoil momentum for burst-fire control, even at its low velocity. A compensator can contribute very little toward burst-fire stability because the ratio of mass of powder gases to bullet mass is small. This condition was one of the primary reasons for choosing a light-weight, high-velocity cartridge, so that bullet muzzle energy can be about equal to the standard round, yet recoil momentum be considerably reduced. Also, the heavier powder charge required to give higher velocities affords more momentum which can be employed by a compensator to reduce muzzle movement and recoil.

B. REFERENCES

Authority for the test is contained in Teletype ORD 12153, dated 2 June 1953, a copy of which is included in Appendix A.

II DESCRIPTION OF MATERIEL

A. The cartridge designed to fire in the modified M2 carbine, and the standard caliber .30 carbine round are compared below for physical properties:

Cartridge Caliber	Bullet Wt., Grains	Charge Wt., Grains	Total Wt., Grains	Cartridge Case Length, Inches	Overall Cartridge Length, Inches	Maximum Diameter of Cartridge Case, In.
.30	110	13.5	193	1.295	1.680	.357
.22	41	18.0	145	1.320	1.700	.375

Performance characteristics of the test cartridge are summarized under "RESULTS" of this report.

B. A standard caliber .30, M2, carbine was modified to fire the caliber .22 cartridge by fitting and chambering a commercial caliber .22 barrel blank and machining the outside contour to that of the standard carbine barrel. It was desired that the caliber .22 barrel have a bore diameter of .219 inch, a groove diameter of .224 inch, and rifling of one turn in 16 inches with uniform, right-hand twist; however, the available blanks had diametral dimensions which were slightly "tighter" than specified. Other modifications to the weapon consisted of modifying the bolt face to accommodate the larger cartridge case base and increasing the strength of the hammer spring. The muzzle was threaded to accommodate a compensator which was designed to minimize muzzle movement, both upward and sidewise. It also reduces recoil in "muzzle-brake" fashion by changing the direction of expanding powder gases. A bipod from a Browning Automatic Rifle was modified to fit the caliber .22 and caliber .30 carbines in order to evaluate their long-range, burst-fire accuracy characteristics. The larger-diameter cartridge case of the caliber .22 cartridge resulted in a reduction of magazine capacity from 15 rounds of caliber .30 to 10 rounds of caliber .22.

C. Dies for making the caliber .22 carbine ammunition were made to fit a Pacific commercial-type hand loading press. Tools to perform the following operations were made: full-length resizing of cartridge case, reaming case neck, trimming case neck, depriming case, repriming case, bullet seating. Crimping dies were not made because only un-cannelured commercial bullets were available. A pressure barrel was made to fit a Universal receiver. The velocity barrel of the Mann type was made by fitting a commercial caliber .22 barrel blank to a Springfield, M1903, action and turning down the outside barrel contour to fit the recoiling v-slide of a Frankford Arsenal machine rest.

D. All of the machine work on the chambering reamers, cartridge loading dies, proof facility weapons and the test carbine was done at the gunsmith shop at the Small Arms and Aircraft Weapons Branch. Cartridge cases were fabricated by shortening commercial Remington .222 cases to the desired length. All ammunition assembling was done at the loading room of the Small Arms and Aircraft Weapons Branch.

E. Photographs of cartridges and weapons are contained in Appendix C of this report.

F. Drawings of the "maximum cartridge case" and "minimum chamber" are contained in Appendix D.

III DETAILS OF TEST

A. PROCEDURES

1. Methods used to design and fabricate test material are listed under DESCRIPTION OF MATERIEL of this report.

2. The test program is outlined in "Test Program for .22 Carbine Ammunition and Weapon", Appendix A. Those phases of the above program involving test methods which are self-explanatory will not further be described in this section.

3. Counter-type, electronic chronographs, employing lumiline (photoelectric) initiators, were used for all velocity measurements.

4. Peak chamber pressures were obtained by use of conventional-type, radial gages with copper cylinders.

5. Ballistic data were obtained by firing through lumiline initiators at 28.5 and 78.5 feet and two make-circuit screens at 580 and 620 feet from the gun muzzle. The first two chronograph initiators were connected to one electronic-type counter chronograph, and the second pair were connected to another identical instrument. Meteorological data were obtained at, or near, the firing position by observing atmospheric temperatures, pressures, relative humidities, wind velocities and wind directions. Test data were reduced by Siacci methods.

6. In establishing velocity-pressure relationships of various propellants, a maximum pressure of 42,000 p.s.i. was selected because this was considered the highest maximum average pressure that would be safe to use in the present carbine mechanism. The highest velocity obtainable within this limitation was desired.

7. The "Moore" accuracy rest was used to learn the basic accuracy of the weapon-ammunition combination, as fired from the shoulder, but with aiming errors eliminated. This is approximated by making a supporting cradle which has the same mass as the "effective mass" of the average shooter's shoulder. This effective mass was determined by Ballistic Research Laboratories at this station in a previous test. The weapon is supported at the butt stock, and sling tension is applied to hold the weapon to the cradle at the fore end. The cradle is free to recoil and has two U-supports which slide in the V-ways of a steel block to insure proper alignment until the bullet leaves the muzzle during initial recoil.

8. APG Photograph No. A90926, Appendix C, shows the test setup employed for determining free recoil energy data.

9. A test has been devised at this station to determine the magnitude and direction of movement, in terms of target dispersion, that a weapon-ammunition combination will give in the first 3 rounds of automatic fire when the weapon is supported in the normal manner for single, aimed shots. The purpose of this test is to compare the relative movement, from first to second shots and from second to third shots, of various weapons. It is realized that closer groups can be fired by assuming a conventional, "burst-fire stance" and by trying to resist gun movement, but variations in holding are so great, from burst to burst, and among shooters, that a very large number of targets must be fired to obtain an accurate comparison among weapons. It has been demonstrated that very uniform shot patterns are obtained with the first-mentioned technique, and these data show the direction and magnitude that the shoulder-fired weapon tends to move when no correcting force is applied. Such data are also useful for designing muzzle compensators.

10. A bipod from a Browning Automatic Rifle was modified to fit both the caliber .22 and the caliber .30 carbines. Shooters assumed the normal prone position behind the weapons, and no weights, sandbags or other stabilizing devices, other than the muzzle compensators, were used.

11. The qualification course for the M1 rifle, Course B using the A Target, was chosen rather than the course of fire for the carbine, because preliminary trials of accuracy and trajectory indicated that the latter course of fire would be too "easy" to give a proper evaluation of the caliber .22 carbine.

B. RESULTS

1. Detail test results of each phase of the program are contained in round-by-round data, Appendix B of this report.

2. A summary of the ammunition tests is listed in the following paragraphs.

a. In establishing a powder charge to give the maximum muzzle velocity within a pressure limitation of 42,000 p.s.i., the following results were obtained:

Powder Type	Powder Charge, Grains	Bullet Type & Wt., Grains	Inst. Velocity at 78', f.p.s.	Breech Pressure, p.s.i., Copper
IMR 4227	15.8	Full Patch - 35	3019	39,900
IMR 4198	*17.5	Sisk - 41	2717	35,140
IMR 4227	14.3	Sisk - 41	2700	40,419
IMR 4198)	16)	Sisk - 41	**2866	41,195
IMR 4227)	2)			

* Case capacity

** Muzzle velocity = 3022 f.p.s., this is the charge used in other phases of the program. The "blend" charge was employed because no standard IMR powder had completely suitable burning characteristics for the new cartridge.

b. Four ten-shot targets at each range, fired from a Mann barrel, gave the following results; in inches:

100 Yards

Cartridge Type	Mean Radius	Mean Vertical Deviation	Mean Horizontal Deviation	Extreme Vertical Deviation	Extreme Horizontal Deviation	Extreme Spread
Caliber .22	.38	.28	.22	1.15	.75	1.20
Caliber .30	1.36	.94	.77	3.40	3.20	4.15

300 Yards

Caliber .22	2.01	1.20	1.41	4.40	5.38	5.97
Caliber .30	3.90	2.80	2.10	11.60	8.80	12.70

c. Ballistic data for the test cartridges are summarized below:

Range, Yards	Cartridge	Remaining Velocity, f.p.s.	Remaining Energy, ft. lb.	Maximum Ordinate, ft.	Ballistic Consideration
0	.22 Carbine	3022	835	0	C6 - .0824
0	.30 Carbine	1974	966	0	(Based on data
					(from FTO.30-
					(I-1(Abridged)
0	.45 Pistol	920	442	0	(Based on TM
					(9-1990
50	.22	2771	703	.01	
50	.30	1769	776	.03	
50	.45	871	396	.12	
100	.22	2418	533	.05	
100	.30	1580	619	.12	
100	.45	830	360	.47	
150	.22	2122	412	.13	
150	.30	1411	493	.30	
150	.45	798	333	1.1	
200	.22	1839	309	.26	
200	.30	1265	397	.59	
200	.45	769	309	2.0	
250	.22	1576	227	.48	
250	.30	1148	327	1.0	
250	.45	743	288	3.4	
300	.22	1338	164	.80	
300	.30	1062	279	1.7	
300	.45	719	270	5.0	
350	.22	1136	118	1.3	
350	.30	962	229	2.5	
350	.45	696	253	7.1	
400	.22	1021	95	2.0	
400	.30	946	222	3.6	
400	.45	673	237	9.6	

d. Five shots of caliber .22 lead-core ball were fired from a carbine at 1/4-inch mild-steel plate at a range of 50 yards, and the test was repeated by using a caliber .30 carbine with M1 ball ammunition. Five complete perforations (projectile through plate) were obtained with the caliber .22 and 5 partial penetrations, having an average depth of .08-inch, resulted from the caliber .30 firing. Photographs Nos. A90837, A90838 and A90839, Appendix C, show all plate penetration comparisons.

e. Firing against 1/2-inch mild-steel plate was eliminated in favor of 1/4-inch homogeneous and 1/4-inch face-hardened plate when it was learned that no 1/2-inch mild steel is used as armor on any vehicles or gun shields. Several rounds of caliber .22 AP bullets had previously been fired at 1/2-inch mild steel and all gave complete perforations; the caliber .30 carbine AP gave only slight bulges on the rear of the same plate.

f. Five caliber .22 AP rounds fired against 1/4-inch homogeneous plate gave 4 complete perforations and 1 complete penetration at a range of 50 yards. The caliber .30 carbine AP gave 5 partial penetrations of an average depth of .09 inch.

g. Five caliber .22 AP rounds fired against 1/4-inch face-hardened plate at a range of 50 yards gave 4 complete perforations and 1 partial penetration of .07 inch. The caliber .30 carbine AP bullet resulted in 5 partial penetrations with an average depth of .03 inch.

h. The maximum range of perforation of the M1 helmet was 350 yards for the caliber .22 carbine and 400 yards for the caliber .30 carbine.

i. The maximum range of perforation of the M12 armored vest was 250 yards for the caliber .22 carbine and 200 yards for the caliber .30 carbine.

3. A summary of weapons tests is listed in the following paragraphs.

a. The average instrumental velocity of ammunition fired in the carbine, using the powder charge selected from the pressure-velocity phase of the test, was 2880 f.p.s. at 78 feet from the muzzle. Corrected to the muzzle, this value is 3037 f.p.s. with the caliber .22, 41-grain Sisk bullet.

b. Dispersion in semi-automatic fire was established by using two expert riflemen, each firing four 10-shot targets with each weapon at each range. Dispersion data, in inches, are averaged below:

100 Yards

Weapon Type	Mean Radius	Mean Vertical Deviation	Mean Horizontal Deviation	Extreme Vertical Deviation	Extreme Horizontal Deviation	Extreme Spread
Caliber 22	1.2	.8	.8	3.2	3.3	4.1
Caliber 30	1.9	1.4	1.0	6.5	4.6	7.0

300 Yards

Caliber 22	4.1	1.9	3.2	8.4	12.7	13.8
Caliber 30	6.5	4.8	3.1	22.3	15.0	24.7

c. Four 10-shot groups were fired at 100 yards with each weapon supported in Moore Accuracy Rest:

Weapon Type	Mean Radius	Mean Vertical Deviation	Mean Horizontal Deviation	Extreme Vertical Deviation	Extreme Horizontal Deviation	Extreme Spread
Caliber .22	.57	.36	.52	1.50	2.30	2.30
Caliber .30	1.75	1.25	.97	5.55	5.00	6.10

d. Energy of free recoil was measured in a pendulum, and 5-round averages are tabulated below. (Weapons were fitted with slings and loaded magazines.)

Weapon Type	Bullet Weight, Grains	Bullet Muzzle Velocity, f.p.s.	Muzzle Compensator	Wt. of Weapon, lb.	Recoil Energy, ft. lb.
Caliber .22	41	3037	With	6.35	1.03
Caliber .22	41	3037	Without	6.30	2.47
Caliber .22	35	3181	With	6.35	.77
Caliber .22	35	3181	Without	6.30	1.85
Caliber .30	110	1975	With	6.40	3.95
Caliber .30	110	1975	Without	6.10	4.63

e. Cyclic rate of fire was 887 and 797 rounds per minute for the caliber .22 and caliber .30 carbines, respectively.

f. Five 3-shot bursts, fired in the normal standing position, were shot by each of three gunners with each weapon at a range of 25 yards. Average distance of shots from the point of aim are tabulated below, in inches:

Weapon Type	First Shot		Second Shot		Third Shot	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
Cal. .22 Carbine	.37	1.47	2.27	1.97	10.48	5.88
Cal. .30 Carbine	.57	2.97	4.52	29.98	29.68	73.99
Cal. .45 Submachine Gun	1.54	6.97	9.85	27.45	21.43	54.00

All of the weapons were fitted with compensators. Second and third shots were usually higher and farther to the right than the preceding shot; however, the caliber .22, being more effectively controlled by the compensator, gave numerous exceptions to this performance characteristic.

g. Burst-fire dispersion was determined by firing five 5-shot bursts by each of two gunners, employing the prone position and bipod. Compensators were used on both the caliber .22 and the caliber .30 carbines. The caliber .30 weapon was not fired at 300 yards, because the patterns at 200 yards could not be contained on the 8-ft. by 8-ft. target. Results, in inches, are tabulated below:

Weapon Type	Range, Yards	Mean Radius	Mean Vertical Deviation	Mean Horizontal Deviation	Extreme Vertical Deviation	Extreme Horizontal Deviation	Extreme Spread
Caliber .22	200	7.2	4.4	4.7	15.1	15.5	20.0
Caliber .22	300	13.24	10.14	7.21	31.25	24.85	38.31

Results of the caliber .30 firing at 200 yards are not summarized, because only 6 of 10 groups had all shots on the 8 ft. x 8 ft. target.

h. Two expert riflemen fired the B Course of fire, for the M1 rifle, which requires the use of the A-Target, having a 10-inch 5-ring, with firing ranges of 200 and 300 yards. A fish-tail wind at about 15 miles per hour was blowing, and shooting was toward the sun. The unfavorable wind condition probably favored the M1 rifle, since the caliber .30 AP bullet has less wind drift than does the caliber .22 bullet. The unfavorable target lighting probably reduced the scores with both weapons approximately the same amount. Scores, out of a possible 210 points, were as follows:

Weapon	Rifleman	Score	Expert Qualification
Caliber .22 Carbine	Perrin	187	185
Caliber .30, M1 Rifle	Perrin	180	185
Caliber .22 Carbine	Gustafson	186	185
Caliber .30, M1 Rifle	Gustafson	178	185

i. A total of 1009 rounds was fired from the caliber .22 carbine during the test and 3 malfunctions resulted: Two failures to extract and one failure to eject. These occurred after about 850 rounds and were caused by lead shaving off the soft-points of the sporting-type bullets and imbedding in the chamber. The chamber was cleaned and no other malfunctions occurred.

C. OBSERVATIONS

1. Only a small quantity of IMR-type propellant of the proper granulation was available for this test, so it was necessary to combine two powders to obtain an "effective web size" to produce the velocity-pressure relationship desired. The goal was to obtain at least 3000 f.p.s. muzzle velocity without exceeding 42000 p.s.i. maximum average breech pressure. This objective, while attained, was only slightly exceeded; however, it is probable that a high-potential, ball-type propellant will give considerably more velocity within the above pressure limitation and have the added advantage of causing less barrel erosion.

2. The mean radial dispersion of the caliber .22 ammunition was only 28% at 100 yards and 52% at 300 yards of that of the unselected lot of caliber .30 ammunition used in this test, when both were fired from Mann-type accuracy barrels. This great decrease in dispersion of the caliber .22 cartridge should improve probability of a hit by a considerable degree if other factors such as marksmanship and trajectory remain unchanged.

3. The maximum ordinate of the caliber .22 cartridge, over a range of 300 yards, is 48% and 16% of the caliber .30 carbine and caliber .45 cartridges, respectively. This "flatness" of trajectory of the caliber .22 cartridge increases hit probability on man-size targets under battlefield conditions, because it makes range estimation errors relatively unimportant and sight changing, within 300 yards unnecessary. With standard carbine sights set to make the bullet hit the point of aim at 250 yards, the highest the bullet would rise above the line of sight would be approximately five inches, and it would strike about seven inches low at 300 yards. With the standard caliber .30 carbine, having the same sight setting, the bullet would rise approximately 12 inches above the line of sight and fall about 15 inches low at 300 yards.

4. Remaining energy of the caliber .22 carbine is only 164 ft. lb. (59% of that of the caliber .30 carbine) at 300 yards; a widely used criterion for fragment lethality is 40 ft. lb. Preliminary wound ballistics studies indicate that small-caliber, high-velocity bullets may have better "killing power" than heavier, larger-caliber bullets of equivalent energy, perhaps because the energy is expended more rapidly when the "v^2" factor is relatively large and the "m" factor is small. This phenomenon, and quantitative values regarding it, will be explored further at the Biophysics Laboratory at Army Chemical Center, where studies of various calibers, bullet weights and velocities are under way for lethality performance.

5. Penetration performance of the caliber .22 bullets, even with the soft-lead-nosed commercial types necessarily employed in this test, was far superior to that of the caliber .30 carbine bullets when fired against hard and soft metal plates. When fired against body armor and helmets, the performance of the two cartridges was approximately equal.

6. Dispersion characteristics of the caliber .22 weapon-ammunition combination were far superior to those of the standard caliber .30 carbine up to 300 yards, thus the hit probability of the weapon is increased.. The basic weapon dispersion and ammunition errors add in quadrature; therefore, the percentage improvement of the combination was not as large as that for the ammunition alone when compared to the caliber .30 carbine and ammunition. It is probable that weapon errors contributed about the same amount to the overall dispersion in both calibers, since the same basic weapon type was used.

7. The higher scores of the caliber .22 carbine, when fired in comparison with the M1 rifle over the B Course of fire, indicate that the test weapon-ammunition combination is capable of delivering effective fire up to 300 yards. The facts that the carbine weighs about 60% as much as the M1 rifle and that each round of ammunition weighs only 35% as much as the caliber .30 round, are very important when considering the number of rounds which can be carried by each rifleman, especially in rough terrain. Most recent combat data indicate that a large percentage of hits from rifle fire are within the 300-yard limit. It appears that a weapon and ammunition designed to be at maximum effectiveness within this range might be the most efficient weapon for many combat requirements.

8. The low energy of free recoil of the caliber .22 carbine, especially when fitted with a compensator, makes it much easier to control in burst fire than are either the caliber .30 carbine or the caliber .45 submachine gun. In 3-round bursts, fired offhand at 25 yards, the distance of the third shot from the point of aim of the caliber .22 was 15% as far as the carbine and 21% as far as the caliber .45. Recoil energy can be further reduced by using a lighter, 35-grain, bullet at a higher velocity. The advantages gained in burst-fire control would be offset by a poorer ballistic coefficient and resulting lower velocity at ranges beyond approximately 200 yards.

9. Five-shot bursts from the caliber .22 carbine averaged 20 inches and 38 inches for 200 and 300 yards, respectively. Shooters were in the prone position, using a bipod and all bursts were very carefully held. In most combat conditions it would not be possible to control the dispersion as well as in this test. However, data show that these are excellent patterns when compared to those of a caliber .30 carbine, fired under the same conditions, and previous tests of conventional weapons

indicate that extremely large targets would be required at these ranges to contain 5-shot bursts. It is beyond the scope of this program to evaluate burst-fire effectiveness from the tactical standpoint, but it is demonstrated that the weapon-ammunition combination gives markedly better burst-fire dispersion patterns than any other foreign, standard, or experimental shoulder-fired weapon tested at this station to date.

10. Good weapon functioning was obtained during the 1009 rounds fired during this test. The 3 stoppages encountered in the caliber .22 carbine were unquestionably caused by lead shavings from commercial-type bullets. However, the tendency to feed the bullet points too low into the chamber should be corrected in future models by increasing the height of the feed ramp, in front of the magazine well, by a slight amount.

11. Bullets with crimping cannelures were not available for this test, however, such a bullet should be designed for any future production of caliber .22 bullets. It will be necessary to design a bullet with the cannelure on its cylindrical portion so that the cartridge case can be crimped into the cannelure to afford rigidity to the assembled cartridge. This crimping prevents accidental bullet separation in the weapon.

D. OBSERVERS

No observers witnessed testing of the weapon or ammunition; however, the following persons witnessed demonstration firing before the test commenced:

1. Colonel R. R. Studler, Office Chief of Ordnance
2. Colonel Crabill, Army Field Forces
3. Lt. Col. E. B. Crossman, Office Chief of Ordnance
4. Lt. Col. Jelley, AFF Liaison Officer, Aberdeen Proving Ground
5. Mr. Ray Holmes, Olin Industries
6. Mr. J. C. Dear, Olin Industries
7. Mr. Robert Drake, Olin Industries

IV CONCLUSIONS

A. It is concluded that:

1. The M2-type carbine is capable of good performance when modified to fire caliber .22, 41 grain bullets to velocities in excess of 3000 feet per second.

2. The caliber .22 carbine performance, when compared with that of the caliber .30, M2 carbine, was markedly superior with respect to velocity, trajectory, penetration, and accuracy in both semi- and full-automatic fire.

3. The caliber .22 bullets have less striking energy than the caliber .30 carbine bullets at all ranges; however, the caliber .22 has more than enough energy to satisfy present criteria for lethality to ranges of at least 400 yards.

4. The extremely good burst-fire dispersion performance, the light weapon and cartridge weight, and the high striking energy at close range, make the caliber .22 carbine worthy of study as a replacement for the caliber .45 submachine gun.

5. The caliber .22 carbine compares favorably with the M1 rifle in firing against regulation targets up to a range of 300 yards.

V RECOMMENDATION

It is recommended that five caliber .22 carbines and 20,000 rounds of ammunition be procured and tested at Aberdeen Proving Ground, in the presence of members from Army Field Forces, Board No. 3, to learn if ammunition of this type offers any military advantages over that now employed in carbines, rifles or submachine guns.

G. A. GUSTAFSON
Chief, Small Arms and
Aircraft Weapons Branch

APPROVED:

T. F. COLLERAN
Director, Development
and Proof Services

B. S. GOODWIN
Acting Chief
Arms and Ammunition Division

APPENDICES

Appendix A - Teletype ORD 12153.
Test Program for .22 Carbine
Ammunition and Weapon.
Appendix B - Round-By-Round Test Data.
Appendix C - APG Photographs
Appendix D - Sketch

53AA-19446

15

Encl 1 to ltr, to OCO-ORD 75 dtd 9-30-53

APPENDIX A

Teletype ORD 12153, dated 2 June 1953.

Test Program for .22 Carbine Ammunition and Weapon.

N

ETO40

EUA213

RR UETGH

1953 JUN 2 15 39
A.P.G.
MARYLAND

DE UEPC 152A

R 021430Z

Date 2 June 53
ACTION TO BE TAKEN BY
D&PS

FM COFORD WASHDC

TO CG ABERDEEN PRGR MD

DA GRNC

FROM ORDTS CARTEN TT ORD 12153 RE FONECON CARTEN-GUSTAFSON CMM REQUEST REPORT ON CALIBER .22 RIFLE DEVELOPMENTS BE PREPARED AND FORWARDED THIS OFFICE PD COSTS CHARGEABLE TO PROJECT TS1-2

CFN 12153 .22 TS1-2

02/1506Z

17

TEST PROGRAM FOR .22 CARBINE AMMUNITION AND WEAPON

I. Ammunition Program

A. Design cartridge case and make rough sketches of "maximum cartridge case" and "minimum barrel chamber". Cartridge case to be of largest capacity to feed through carbine magazine.

B. Fabricate a Mann accuracy barrel, and a pressure barrel for Universal receiver. Rifled barrel blanks to be obtained from custom barrel maker, and all machine work, including making chambering reamers, to be done at Small Arms and Aircraft Weapons Branch gunsmithing shop.

C. Fabricate reloading dies to fit Pacific loading press.

D. Using commercial or special bullets of approximately 40 grains weight, establish the highest velocity possible within pressure limitations of 42,000 p.s.i., copper.

E. Design and produce armor-piercing bullets of approximately 35 grains weight.

F. Using the load selected in Paragraph D, conduct the following tests:

1. Fire 20 rounds for velocity from the Mann barrel. (+70°F)

2. Fire 20 rounds for breech pressure from the pressure barrel.

3. Fire four ten-shot targets at 100 yards from the Mann barrel. Use caliber .30 carbine cartridge for control.

4. Fire four ten-shot targets at 300 yards from the Mann barrel. Use caliber .30 carbine cartridge for control.

5. Determine the ballistic coefficient and calculate striking velocity and energy at 0, 50, 100, 200, 300 and 400 yards. Compare these figures to those of the cal. .45 cartridge fired from the M3A1 submachine gun and the cal. .30 carbine cartridge.

6. Fire 5 shots at a 1/4-inch mild steel plate at 50 yards using the lead-core ball. Fire the carbine for control and photograph the plate after depth of penetration is measured.

7. Fire 5 shots at a 1/2-inch mild steel plate at 50 yards using the armor-piercing bullet. Fire the AP bullet in the cal. .30 carbine for control. Measure depth of penetration and photograph plate.

8. Determine the maximum range, not to exceed 400 yards, that the lead-core ball will penetrate the M1 helmet and standard body armor. Use the ball cartridge for the cal. .30 carbine for comparison.

II Weapon Program

A. Modify a standard M2 cal. .30 carbine to fire the cartridge developed in Phase I of this program.

B. Design and fabricate a muzzle compensator which will balance muzzle climb in burst fire, by utilizing the momentum of the propellant gases.

C. Fit a bipod to the weapon in such a manner that it can be removed when not in use.

D. Employing the ammunition developed in Phase I, conduct the following program:

1. Fire 20 rounds for velocity from .22 carbine.

2. Keep a record of gun functioning for all tests, including demonstrations.

3. Establish semi-automatic dispersion characteristics by firing four 10-shot groups at 100 yards and at 300 yards range. Fire the cal. .30 carbine for comparison. An expert shooter using a bench rest should do all the firing under similar weather conditions.

4. Fire four 10-shot dispersion targets at 100 yards using the "Moore Accuracy Rest". Use a cal. .30 M2, carbine for control.

5. Determine the recoil characteristics of the weapon-ammunition combination, with gun fitted with the compensator, by firing on a recoil pendulum. Repeat the test without the compensator. Use a cal. .30 carbine for comparison, both with and without compensator.

6. Evaluate and compare automatic-fire dispersion characteristics in 3-round bursts at 25 yards. The technique employed in previous tests should be used, and the cal. .30 carbine and Thompson submachine gun should be employed for comparison.

7. Determine burst fire accuracy from the prone position with weapon equipped with bipod. Two expert gunners should fire five 5-shot groups each at a range of 200 yards. Use a cal. .30 carbine with compensator for comparison.

8. Fire the qualification course for the M1 rifle, employing two expert riflemen shooting the test weapon. Repeat the firing with the cal. .30, M1 rifle and the M2 cal. .30 carbine for comparison.

APPENDIX B

Round-By-Round Test Data

Four velocity uniformity series were fired from the .224 Carbine Mann Barrel.

The results are as follows for 20 rounds per load:

1. 35 gr. W.R.A. Full Patch
   15.8 grs. #4227 — Mean Velocity 3019 f.p.s.

2. 41 gr. Sisk
   17.5 grs. #4198 — Mean Velocity 2717 f.p.s.

3. 41 gr. Sisk (40 rounds)
   14.3 grs. #4227 — Mean Velocity 2700 f.p.s.

4. 41 gr. Sisk
   16 grs. #4198, 2 grs. #4227 — Mean Velocity 2866 f.p.s.

30 June 1953

Test of: Velocity Uniformity and 100 Yard Accuracy - .224 Carbine

17.5 grs. 4198 41 gr. Sisk

ROUND	VELOCITY
1	2793
2	2681
3	2747
4	2716
5	2747
6	2681
7	2698
8	2655
9	2690
10	2674
11	2735
12	2747
13	2648
14	2772
15	2688
16	2737
17	2743
18	2740
19	2744
20	2706

Average Velocity = 2717 fps

CHRONOGRAPH VELOCITY REPORT

30 June 1953

Proof Director: Mr. Steph

Program: Caliber 22

Gun to 1st Coil: 53.00'

1st to 2nd Coil: 50.00'

Projectile: 17 1/2 grs.

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VELOCITY
1	1551	1796	2793
2		1865	2681
3		1820	2747
4		1841	2716
5		1820	2747
6		1865	2681
7		1853	2698
8		1883	2655
9		1859	2690
10		1870	2674
11		1828	2735
12		1820	2747
13		1888	2648
14		1804	2772
15		1860	2688
16		1827	2737
17		1823	2743
18		1825	2740
19		1822	2744
20	1602	1848	2706

Test of: .224 Carbine-Velocity Uniformity-Mann Barrel

16 grs. #4198 2 grs. #4227 41 gr. Sisk

ROUND	VELOCITY
1	2854
2	2874
3	2828
4	2885
5	2836
6	2870
7	2879
8	2897
9	2895
10	2859
11	2822
12	2885
13	2890
14	2885
15	2843
16	2890
17	2880
18	2851
19	2859
20	2838
Mean	2866 fps

CHRONOGRAPH VELOCITY REPORT

2 July 1953

Proof Director: Steph

Program: Caliber .22

Gun to 1st Coil: 53.00'

1st to 2nd Coil: 50.00'

Projectile: 16 gr. #4198 2 gr. #4227

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VELOCITY
1	1519	1752	2854
2		1740	2874
3		1768	2828
4		1733	2885
5		1763	2836
6		1742	2870
7		1737	2879
8		1726	2897
9		1727	2895
10		1749	2859
11		1772	2822
12		1733	2885
13		1730	2890
14		1733	2885
15		1759	2843
16		1730	2890
17		1736	2880
18		1754	2851
19		1749	2859
20	1524	1762	2838

Test of: Velocity Accuracy - .224 Carbine 20 June 1953

15.5 gr. #4227 14.3 gr. #4227 41 gr. Sisk

ROUND	VELOCITY
1	2887
2	2934
3	2892
4	2927
5	2877
6	2678
7	2726
8	2720
9	2717
10	2725
11	2737
12	2723
13	2707
14	2695
15	2713
16	2690
17	2707
18	2680
19	2668
20	2716
21	2740
22	2719
23	2688
24	2709
25	2662
26	2707
27	2714
28	2670
29	2661
30	2671
31	2657
32	2674
33	2726
34	2709
35	2655
36	2711
37	2720
38	2728
39	2711
40	2706
41	2701
42	2698
43	2677
44	2709
45	2671

Test of: Velocity Accuracy - .224 Carbine (Cont'd)
15.8 gr. #4227 35 gr. Bullet

ROUND	VELOCITY
46	3016
47	3023
48	3043
49	3008
50	3045
51	3030
52	3003
53	3003
54	3025
55	2967
56	3016
57	3028
58	2990
59	2996
60	2983
61	3071
62	3041
63	3007
64	3038
65	3049

Mean Velocity = 3019 fps

CHRONOGRAPH VELOCITY REPORT

Proof Director: Mr. Perrin

Program: .224 Carbine

20 June 1953

Gun to 1st Coil: 53.00'

1st to 2nd Coil: 50.00'

ROUND NO.	COIL TIME	INSTRUMENT VELOCITY	PROJECTILE
1	1732	2887	15.5 gr.
2	1704	2934	
3	1729	2892	
4	1708	2927	
5	1738	2877	
6	1867	2678	14.3 gr.
7	1834	2726	
8	1838	2720	
9	1846	2717	
10	1835	2725	
11	1827	2737	
12	1836	2723	
13	1847	2707	
14	1855	2695	
15	1843	2713	
16	1859	2690	
17	1847	2707	
18	1866	2680	
19	1874	2668	
20	1841	2716	
21	1825	2740	
22	1839	2719	
23	1860	2688	
24	1846	2709	
25	1878	2662	
26	1847	2707	
27	1842	2714	
28	1873	2670	
29	1879	2661	
30	1872	2671	
31	1882	2657	
32	1870	2674	
33	1834	2726	
34	1846	2709	
35	1883	2655	
36	1844	2711	
37	1838	2720	
38	1833	2728	
39	1844	2711	
40	1848	2706	

CHRONOGRAPH VELOCITY REPORT

ROUND NO.	COIL TIME	INSTRUMENT VELOCITY	PROJECTILE
41	1851	2701	
42	1853	2698	
43	1868	2677	
44	1846	2709	
45	1872	2671	
46	1658	3016	15.8 gr.
47	1654	3023	
48	1643	3043	
49	1662	3008	
50	1642	3045	
51	1650	3030	
52	1665	3003	
53	1665	3003	
54	1653	3025	
55	1685	2967	
56	1658	3016	
57	1651	3028	
58	1672	2990	
59	1669	2996	
60	1676	2983	
61	1628	3071	
62	1644	3041	
63	1663	3007	
64	1646	3038	
65	1640	3049	

Four complete pressure series were fired from the .224 Carbine pressure barrel with Universal receiver No. 197. The results are summarized as follows for 20 rounds each:

1.	35 gr. W.R.A. Full Patch bullet 15.8 grs. #4227	Mean Pressure Mean Velocity	39,990 psi 2964 fps
2.	41 gr. Sisk 17.5 grs. #4198	Mean Pressure Mean Velocity	35,140 psi 2716 fps
3.	41 gr. Sisk 14.3 grs. #4227	Mean Pressure Mean Velocity	40,419 psi 2691 fps
4.	41 gr. Sisk 16 grs. #4198, 2 grs. #4227	Mean Pressure Mean Velocity	41,195 psi 2859 fps

Test of: Pressure Series - .22-4 Carbine

16 grs. #4198, 2 grs. #4227, 41 gr. Sisk

Velocity at 78'

ROUND	VELOCITY	PRESSURE	REMARKS
1	2943	45600	(10 grs. #4198 - 8 grs. #4227 (Cp 26-43 - L29 (41 gr. Bullet
2	2894	42600	14 grs. #4198 - 4 grs. #4227
3	2976	51000	4 grs. #4227 - 14 grs. #4198
4	2800	41900	9 grs. #4198 - 8 grs. #4227
5	2849	39400	15 grs. #4198 - 3 grs. #4227
6	2870	42000	15 grs. #4198 - 3 grs. #4227
7	2884	42600	15 grs. #4198 - 3 grs. #4227
8	2860	43600	15 grs. #4198 - 3 grs. #4227
9	2817	36000	16 grs. #4198 - 2 grs. #4227
10	2840	40400	
11	2828	40800	
12	2884	42200	
13	2890	43400	
14	2917	45600	
15	2856	39800	
16	2856	41200	
17	2807	38600	
18	2904	42000	
19	2836	39800	
20	2862	40400	
21	2847	40900	
22	2892	42400	
23	2852	42100	Avg. Pres. 41,195
24	2864	42000	
25	2877	43500	
26	2854	40800	
27	2877	42900	
28	2820	39100	

Test of: .224 Carbine Pressure Barrel

Pressure Series - 35 gr. W.R.A. 15.8 grs. #4227

19 June 1953

Velocity at 78 feet

ROUND	VELOCITY	PRESSURE	REMARKS	
1	2867	46700	41 gr. - 15.5 - #4227	L29
2	2862	54300		
3	2860	47400		
4	2870	49200		
5	2843	47600		
6	2867	50400		
7	2982	41500	35 gr. - 15.8 - #4227	L29
8	2955	39000		
9	2941	39200		
10	2994	41700		
11	2962	40400		
12	2952	40600		
13	2938	38600		
14	2971	39700		
15	2989	41800		
16	3012	41600		
17	2976	39700		
18	2967	39100		
19	2950	37800		
20	2957	40200		
21	2952	39900		
22	2895	38400		
23	2964	38800		
24	2973	41200		
25	2974	40900		
26	2983	40200		
27	2966	41000		

Test of: Pressure Series - .224 Carbine

17.5 grs. #4198, 41 gr. Sisk

1 July 1953

ROUND	VELOCITY	PRESSURE	REMARKS
1	2716	35000	17.5 grs. #4198
2	2729	34200	41 gr. Sisk
3	2765	37800	
4	2767	37400	
5	2713	34600	
6	2719	35300	
7	2585	33800	
8	2682	36600	
9	2764	37000	
10	2704	34000	
11	2678	34000	
12	2713	33000	
13	2722	35000	
14	2753	35200	
15	2728	33300	
16	2735	35100	
17	2726	35900	
18	2716	36500	
19	2670	32100	
20	2732	36600	

Test of: Pressure - .224 Carbine -

1 July 1953

ROUND	VELOCITY	PRESSURE	REMARKS
1	2775	42400	15.5 grs. #4227 Lot 15-C
2	2801	44100	
3	2781	45300	
4	2927	45400	15.7 grs. #4227 Lot 29 A.P. Bullet
5	2844	43800	
6	2872	36200	

Test of: .224 Carbine Pressure Barrel

Pressure Series - 14.3 grs. #4227, 41 gr. Sisk

19 June 1953

ROUND	VELOCITY	PRESSURE	REMARKS
1	2680	38500	41 gr. Bullet 14.3 grs. #4227 L29
2	2693	38800	
3	2693	39400	
4	2678	38200	
5	2698	42700	
6	2688	40400	
7	2703	40700	
8	2706	41000	
9	2688	40000	
10	2709	42600	
11	2677	38000	
12	2678	44000	
13	2703	42000	
14	2710	41600	
15	2682	38500	
16	2693	39800	
17	2680	37400	
18	2706	42400	
19	2672	40200	
20	2709	45900	
21	2668	36700	
23	2738	42400	14.5 grs. #4227
24	2738	42600	
25	2767	44000	14.7 grs. #4227 - 41 gr.
26	2765	43000	14.7 grs. #4227 - 41 gr.

CHRONOGRAPH VELOCITY REPORT

1 July 1953

Proof Director: Mr. Steph

Program: Caliber .22

Gun to 1st Coil: 53.00 feet

1st to 2nd Coil: 50.00 feet

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VELOCITY	PROJECTILE
1	0915	1841	2716	17 1/2 gr. #4198
2		1832	2729	
3		1808	2765	
4		1807	2767	
5		1843	2713	
6		1839	2719	
7		1934	2585	
8		1864	2682	
9		1809	2764	
10		1849	2704	
11		1867	2678	
12		1843	2713	
13		1837	2722	
14		1816	2753	
15		1833	2728	
16		1828	2735	
17		1834	2726	
18		1841	2716	
19		1873	2670	
20		1830	2732	

CHRONOGRAPH VELOCITY REPORT

1 July 1953

Proof Director: Mr. Steph

Program: Caliber .22

Gun to 1st Coil: 53.00 feet

1st to 2nd Coil: 50.00 feet

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VELOCITY	PROJECTILE
1	1000	1802	2775	15 1/2 grs. #4227 Lot 15-C
2		1775	2801	
3		1798	2781	
4		1708	2927	15.7 gr. #4227 Lot 29
5		1758	2844	
6		1741	2872	
7		1699	2943	(10 grs. #4198 (8 grs. #4227
8		1728	2894	(14 grs. #4198 (4 grs. #4227

CHRONOGRAPH VELOCITY REPORT

1 July 1953

Proof Director: Mr. Perrin

Program: Caliber .22

Gun to 1st Coil: 53.00 feet

1st to 2nd Coil: 50.00 feet

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VELOCITY	PROJECTILE
1	1259	1680	2976	4 gr. #4227 4 gr. #4198
2	1302	1786	2800	9 gr. #4198 8 gr. #4227
3	1314	1755	2849	15 gr. #4198 3 gr. #4227
4	1341	1742	2870	
5	1344	1734	2884	
6	1346	1748	2860	
7	1508	1775	2817	16 gr. #4198 2 gr. #4227
8	1609	1760	2840	
9	1611	1768	2828	
10	1614	1734	2884	
11	1615	1730	2890	
12	1616	1714	2917	
13	1618	1751	2856	
14	1616	1751	2856	
15	1619	1781	2807	
16	1622	1722	2904	
17	1548	1763	2836	
18	1550	1747	2862	
19	1552	1756	2847	
20	1555	1729	2892	
21	1557	1753	2852	
22	1559	1746	2864	
23	1601	1738	2877	
24	1603	1752	2854	
25	1605	1738	2877	
26	1607	1773	2820	

BALLISTIC-FIRING REPORT

15 June 1953

Caliber: .224 Carbine

Cartridge Type and Lot: 41 gr. Sisk Lovell, 15.5 grs. IMR 4227

Screen Distances from Muzzle, First Pair: 28.5 ft. 78.5 ft.
Second Pair: 580.0 ft. 620.0 ft.

Temperature: 72°F. Relative Atmospheric Density: .994

TIME FIRED	ROUND NO.	1st IV fps	2nd IV fps	WIND VELOCITY fps	COS WIND DIRECTION	RANGE COMP. WIND fps
1050	1	2941	1877	3	+ .7	+2
1105	2	2874	Lost	3	+ .9	-
1108	3	2939	Lost	2	+ .1	-
1118	4	2904	Lost	2	+ .6	-
1123	5	Lost	Lost	4	+ .9	-
1127	6	2929	Lost	3	+ .1	-
1135	6	2946	1872	3	- .1	0
1137	7	2934	1818	3	-1.0	-3
1139	8	2939	Lost	4	+ .7	-
1142	9	2914	1809	2	+ .9	+2
1144	10	2966	1859	0	--	0
1146	11	2921	1832	5	+ .8	+4
1148	12	2939	1807	1	0	0
1149	13	2964	Lost	2	+1.0	-
1151	14	2938	Lost	6	+ .3	-
1159	15	2895	1814	1	+ .9	+1
1161	16	2943	1804	2	+1.0	+2
1162	17	2899	1832	5	+ .8	+4

Determination of Mean Ballistic Coefficient and the Probable Error of the Mean over 200 Yard Range

41 gr. Sisk Lovell 15.5 gr. IMR 4227

Screens: 28.5' 78.5'
580.0' 620.0'

ROUND NO.	C6
1	.0860
6	.0831
7	.0797
9	.0804
10	.0806
11	.0816
12	.0786
15	.0822
16	.0779
17	.0833
Mean	.0813

Standard deviation $\sigma = 23.01 \times 10^{-4}$

Standard error of mean $\sigma_{\bar{c}} = \frac{\sigma}{\sqrt{N-1}} = \frac{23.01 \times 10^{-4}}{3} = 7.67 \times 10^{-4}$

Probable error of mean $PE_{\bar{c}} = .6745\,\sigma_{\bar{c}} = 5.17 \times 10 = .0005$

BALLISTIC-FIRING REPORT

15 June 1953

Caliber: .224 Carbine

Cartridge Type and Lot: 41 Gr. Sisk Lovell 15.5 Grs. IMR 4227

Screen Distances from Muzzle, First Pair: 28.5 ft. 78.5 ft.
Second Pair: 1180.0 ft. 1220.0 ft.

Temperature: 77°F. Relative Atmospheric Density: .983

TIME FIRED	ROUND NO.	1st IV fps	2nd IV fps	WIND VEL. fps	COS WIND DIR.	RANGE COMP. WIND	REMARKS
1439	1	2927	Lost	3	+ .6		
1444	2	2985	Lost	0	--		
1450	3	2905	Lost	0	--		
1456	4	2905	1044	4	- 1	-4	
1458	5	2959	1055	3	- .8	-2.4	
1459	6	2980	Lost	0	--		
1501	7	2938	1032	1	- 1	-1	
1502	8	2973	Lost	2	- 1		
1505	9	2892	1051	0	--	0	
1506	10	2971	Lost	0	--		
1509	11	2955	Lost	2	- .9		
1507	12	2948	1016	6	-1		Grazed Wood Strip
1508	13	2960	Lost	3	-1		
1515	14	2948	Lost	4	-1		
1519	15	2967	1031	2	-1	-2	
1520	16	2943	Lost	2	.9		Start, no stop
1521	17	2941	Lost	4	-1		Start, no stop
1525	18	2929	Lost	0	--		
1528	19	2953	1040	3	-1	-3	
1529	20	2919	Lost	3	-1		
1530	21	2939	Lost	5	-1		
1538	22	2936	Lost	3	- .7		
1542	23	2964	Lost	4	- .9		
1545	24	2969	1032	3	-1	-3	
1549	25	2912	1078	3	- .9	-2.7	
1551	26	2885	Lost	3	-1		
1555	27	2936	Lost	1	-1		
1559	28	2889	1059	0	--	0	
1601	29	2922	1058	0	--	0	

Determination of Mean Ballistic Coefficient and the Probable Error of the Mean over 400 Yard Range

41 Gr. Sisk Lovell 15.5 Gr. IMR 4227

Screens: 28.5 feet 78.5 feet
1180.0 feet 1220.0 feet

ROUND NO.	C_6
4	.0843
5	.0842
7	.0814
9	.0832
15	.0804
19	.0820
24	.0806
25	.0881
28	.0863
29	.0848
Mean	.0835

Standard deviation $\sigma = 23.79 \times 10^{-4}$

Standard error of mean $\sigma_{\bar{c}} = \frac{\sigma}{\sqrt{N-1}} = \frac{23.79 \times 10^{-4}}{3} = 7.93 \times 10^{-4}$

Probable error of mean $PE_{\bar{c}} = .6745\,\sigma_{\bar{c}} = 5.35 \times 10^{-4} = .0005$

Data for .224 Carbine

41 gr. Sisk Super-Lovell, 16 grs. #4198, 2 grs. #4227

RANGE yards	STRIKING VELOCITY fps	STRIKING ENERGY ft. lbs.	MAXIMUM ORDINATE ft.
0	3022	835	0
50	2771	703	.01
100	2418	533	.05
150	2122	412	.13
200	1839	309	.26
250	1576	227	.48
300	1338	164	.80
350	1136	118	1.3
400	1021	95	2.0

BALLISTIC-FIRING REPORT

15 June 1953

Caliber: .224 Carbine

Cartridge Type and Lot: 35 Gr. WRA Full-Patch, 16.1 Grs. IMR 4227

Screen Distances from Muzzle, First Pair: 28.5 feet 78.5 feet
Second Pair: 580.0 feet 620.0 feet

Temperature: 75°F. Relative Atmospheric Density: .988

TIME FIRED	ROUND NO.	1st IV fps	2nd IV fps	WIND VEL. fps	COS WIND DIR.	RANGE COMP. WIND	REMARKS
1335	1	3003	1849	5	- .9	-4.5	
1337	2	3073	1900	3	- .8	-2.4	
1339	3	3053	1916	0	--	0	
1341	4	3060	1899	3	- .6	-1.8	
1342	5	3028	Lost	0	--	0	
1345	6	2998	1825	3	- .9	-2.7	Hit wire - Lost.
1349	7	3045	Lost	2	- .9	-1.8	
1352	8	2976	1844	2	-1	-2	
1354	9	2985	1829	0	--	0	
1355	10	3028	1883	0	--	0	
1357	11	3032	1874	0	--	0	
1359	12	3023	1868	0	--	0	
1400	13	2980	Lost	0	--	0	
1401	14	3106	1948	0	--	0	

Determination of Mean Ballistic Coefficient and Probable Error of the Mean over 200 Yard Range.

35 gr. WRA Full-Patch
16.1 grs. IMR 4227

Screens: 28.5 feet 78.5 feet
580.0 feet 620.0 feet

ROUND NO.	C_6
1	.0772
2	.0761
3	.0786
4	.0767
8	.0785
9	.0767
10	.0779
11	.0769
12	.0771
14	.0774
Mean	.0773

Standard deviation $\sigma = 7.662 \times 10^{-4}$

Standard error of mean $\sigma_{\bar{c}} = \frac{\sigma}{\sqrt{N-1}} = \frac{7.662 \times 10^{-4}}{3} = 2.55 \times 10^{-4}$

Probable error of mean $PE_{\bar{c}} = .6745\,\sigma_{\bar{c}} = 1.72 \times 10^{-3} = .0001$

BALLISTIC-FIRING REPORT

15 June 1953

Caliber: .224 Carbine

Cartridge Type and Lot: 35 Gr. WRA Full-Patch, 16.1 Grs. IMR 4227

Screen Distances from Muzzle, First Pair: 28.5 feet 78.5 feet
Second Pair: 1180.0 feet 1220.0 feet

Temperature: 76°F. Relative Atmospheric Density: .985

TIME FIRED	ROUND NO.	1st IV fps	2nd IV fps	WIND VEL.	COS WIND DIR.	RANGE COMP. WIND
1603	1	3073	1069	0	--	0
1606	2	3010	1052	0	--	0
1607	3	3090	1069	3	+.6	+1.8
1608	4	3021	980	3	+.8	+2.4
1609	5	2945	Lost	2	-.5	
1610	6	2985	1052	2	-.6	-1.2
1611	7	3051	1058	0	--	0
1612	8	3010	1052	2	-.7	-1.4
1613	9	3081	1065	0	--	0
1614	10	2987	1041	0	--	0
1615	11	3016	1050	0	--	0

Determination of Mean Ballistic Coefficient and the Probable Error of the Mean over 400 Yard Range

35 gr. WRA Full-Patch
16.1 gr. IMR 4227

Screens: 28.5 feet, 78.5 feet
1180.0 feet, 1220.0 feet

ROUND NO.	C_6
1	.0808
2	.0811
3	.0800
6	.0822
7	.0804
8	.0813
9	.0801
10	.0807
11	.0807
Mean	.0808

Standard deviation $\sigma = 6.33 \times 10^{-4}$

Standard error of mean $\sigma_{\bar{c}} = \frac{\sigma}{\sqrt{N-1}} = 1.827 \times 10^{-4}$

Probable error of mean $PE_{\bar{c}} = .6745\,\sigma_{\bar{c}} = 1.23 \times 10^{-4} = .0001$

Data for .224 Carbine

35 gr. WRA Full-Patch Bullet, 15.8 grs. IMR #4227

RANGE yards	STRIKING VELOCITY fps	STRIKING ENERGY ft. lbs.	MAXIMUM ORDINATE ft.
0	3181	791	0
50	2704	571	.02
100	2389	446	.08
150	2081	338	.17
200	1789	250	.32
250	1520	181	.56
300	1402	154	.72
350	1091	92	1.5
400	990	77	2.3

Data for Caliber .30 Carbine based on FT 0.30-I-1 (Abridged)

IV = 1900 fps at 53 feet

C_1 = 0.179

RANGE yards	STRIKING VELOCITY fps	STRIKING ENERGY ft. lbs.	MAXIMUM ORDINATE ft.
0	1974	966	0
50	1769	776	.03
100	1580	619	.12
150	1411	493	.30
200	1265	397	.59
250	1148	327	1.0
300	1062	279	1.7
350	962	229	2.5
400	946	222	3.6

* Data for Caliber .45 M1A1 and M3 Based on TM9-1990, p. 110, Table XLIII (Sept. 1947)

RANGE yards	STRIKING VELOCITY fps	STRIKING ENERGY ft. lbs.	MAXIMUM ORDINATE ft.
0	920	442	0
50	871	396	.12
100	831	360	.47
150	798	333	1.1
200	769	309	2.0
250	743	288	3.4
300	719	270	5.0
350	696	253	7.1
400	673	237	9.6

* Velocities taken from TM 9-1990.

ACCURACY TEST

DATE: 3 July 1953 RANGE: 100 Yards

FIRED FROM: Closed Range #1

CARTRIDGE: 14.7 grs. #2400, 41 gr. Sisk

RIFLE: .224 Carbine Mann Barrel

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	.37	.32	.14	1.0	.5	1.0
	2	.43	.23	.32	1.2	1.1	1.3
	3	.35	.30	.18	1.1	.7	1.3
	4	.39	.29	.23	1.3	.7	1.3
Mean		.38	.28	.22	1.15	.75	1.2

ACCURACY TEST

DATE: Fired 20 June 1953 RANGE: 100 Yards

FIRED FROM: Closed Range #2

WIND: 0

CARTRIDGE: .224 Carbine, 14.3 grs. #4227, 41 gr. Sisk

RIFLE: Mann Barrel

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	.606	.400	.382	1.55	1.55	2.17
	2	.647	.424	.423	1.82	1.30	2.19
	3	.508	.297	.308	1.48	1.40	1.60
	4	.415	.277	.251	1.42	.91	1.47
Mean		.544	.350	.341	1.57	1.29	1.86
		35 gr. WRA F-P 15.8 grs. #4227					
	5	1.375	1.02	.792	3.37	2.15	3.60
	6	1.12	.728	.792	2.93	2.58	3.75
Mean		1.25	.82	.792	3.15	2.31	3.64

ACCURACY TEST

DATE: Fired 20 June 1953 RANGE: 100 Yards

FIRED FROM: Closed Range #2

WIND: 0

CARTRIDGE: .30 Carbine Ball, Lot 6602

RIFLE: Mann Accuracy Barrel

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	1.167	.95	.54	4.08	2.10	4.07
	2	1.32	1.03	.71	3.2	3.6	4.8
	3	1.36	.81	.86	2.9	2.7	3.0
	4	1.60	.98	.98	3.6	4.4	4.65
Mean		1.36	.94	.77	3.4	3.2	4.15

ACCURACY TEST

DATE: Fired 23 June 1953 RANGE: 300 Yards

FIRED FROM: Romney Creek Firing House

WIND: 0

CARTRIDGE: .22L Carbine, 14.7 grs. #2400, 41 gr. Sisk. RIFLE: Mann Barrel.

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	1.51	.95	.97	3.4	3.4	4.0
	2	1.77	.67	1.47	3.8	5.4	5.7
	3	2.03	1.22	1.47	4.4	5.5	6.0
	4	2.72	1.95	1.71	5.9	7.2	8.2
Mean		2.01	1.20	1.41	4.4	5.38	5.97

ACCURACY TEST

DATE: 23 June 1953 RANGE: 300 Yards

FIRED FROM: Romney Creek

WIND: 0

CARTRIDGE: .30 Carbine Ball, Lot 6602

RIFLE: Mann Barrel

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	3.5	2.5	2.1	8.7	8.5	9.7
	2	3.6	2.6	2.1	12.4	7.9	12.7
	3	4.8	4.2	1.8	15.5	6.9	15.8
	4	3.7	2.0	2.5	9.8	12.1	12.7
Mean		3.9	2.8	2.1	11.6	8.8	12.7

ACCURACY TEST

DATE: 6 July 1953 RANGE: 100 Yards

FIRED FROM: Closed Range #1
Moore Accuracy Rest

CARTRIDGE: 14.3 grs. #4227, 41 gr. Sisk

RIFLE: .224 Carbine Weapon

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	.64	.34	.49	1.40	1.9	1.95
	2	.75	.31	.59	1.5	2.80	2.8
	3	.95	.48	.68	1.9	3.1	3.2
	4	.50	.33	.31	1.2	1.4	1.4
Mean		.57	.36	.52	1.5	2.3	2.3

ACCURACY TEST

DATE: 8 July 1953 RANGE: 100 Yards

FIRED FROM: Closed Range #1
Moore Accuracy Rest

WIND:

CARTRIDGE: .30 Carbine Ball, L6602

RIFLE: .30 Carbine Weapon

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
	1	1.8	1.4	.9	5.7	3.8	6.0
	2	1.9	1.3	1.2	5.1	5.4	6.6
	3	1.6	1.2	.8	4.8	3.6	5.1
	4	1.7	1.1	1.0	6.6	3.2	6.7
Mean		1.75	1.25	.97	5.55	4.0	6.1

ACCURACY TEST

DATE: 21 July 1953 RANGE: 100 Yards

FIRED FROM: L.R. Range & **Romney Cr. B.R. SKY CONDITION: Hazy*

WIND: *** 0

CARTRIDGE: .224 Carbine, 41 gr. Sisk, 14.3 grs. #4227

Semi-automatic dispersion

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
Gustafson	1	1.2	.8	.7	3.8	4.0	4.0
Gustafson	2	1.3	1.1	.9	4.1	2.8	4.1
Gustafson	3	1.3	.9	.7	4.2	2.6	4.5
Gustafson	4	1.5	.9	1.1	3.8	3.4	4.9
Perrin	1	1.2	.4	1.0	1.9	4.6	4.5
Perrin	2	1.0	.6	.7	3.4	3.3	3.8
Perrin	3	1.2	1.0	.6	2.3	3.9	4.2
Perrin	4	1.1	.7	.6	2.3	2.3	2.9
Mean(Gustafson)		1.3	.9	.8	4.0	3.2	4.4
Mean (Perrin)		1.1	.7	.8	2.5	3.5	3.8
Mean (Total)		1.2	.8	.8	3.2	3.3	4.1

* Brilliant sun when Perrin fired. Hazy for Gustafson.
** Perrin fired at Romney Creek.
*** No wind when Gustafson fired. 4-5 mph wind when Perrin fired, across the line of fire.

ACCURACY TEST

DATE: 21 July 1953

RANGE: 100 Yards

FIRED FROM: ** Light Rifle Range B.R.

SKY CONDITION: *** Hazy

WIND: * 0

Semi-automatic dispersion characteristics.

CARTRIDGE: .30 Carbine

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
Gustafson	1	2.2	1.5	1.3	5.5	7.3	8.5
Gustafson	2	1.6	1.3	.7	4.8	3.3	4.9
Gustafson	3	2.0	1.7	.8	8.1	3.6	8.3
Gustafson	4	1.1	.7	.6	4.7	2.8	5.1
Perrin	1	2.5	2.1	1.3	10.0	6.1	11.7
Perrin	2	2.1	1.6	1.0	7.7	4.0	6.0
Perrin	3	1.9	1.0	1.3	4.8	5.0	5.2
Perrin	4	1.8	1.3	.9	6.5	5.1	6.0
Mean (Gustafson)		1.7	1.3	.8	5.8	4.2	6.7
Mean (Perrin)		2.1	1.5	1.1	7.2	5.0	7.2
Mean (Total)		1.9	1.4	1.0	6.5	4.6	7.0

*** Brilliant sun when Perrin fired.
** Perrin fired from Romney Creek bench rest.
* No wind blowing when Gustafson fired. When Perrin fired, there was a strong cross wind of 4-5 mph.

ACCURACY TEST

DATE: 22 July 1953 RANGE: 300 Yards

FIRED FROM: Romney Creek B.R. SKY CONDITION: Bright Sun

WIND: 5-6 mph line of fire

CARTRIDGE: .224 Carbine, 41 gr. Sisk, 14.3 grs. #4227

Semi-automatic dispersion.

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
Perrin	1	3.8	1.2	3.4	6.4	12.6	12.6
Perrin	2	3.8	2.1	2.5	10.7	9.1	11.1
Perrin	3	2.7	1.5	2.0	7.2	7.9	9.9
Perrin	4	4.7	1.5	4.0	5.9	16.1	16.3
Gustafson	1	3.3	2.1	2.3	6.8	11.3	12.1
Gustafson	2	5.7	1.8	5.2	8.1	18.5	19.2
Gustafson	3	5.2	3.0	3.6	14.9	12.4	15.1
Gustafson	4	3.6	2.0	2.5	8.3	13.5	13.9
Average		4.1	1.9	3.2	8.4	12.7	13.8

ACCURACY TEST

DATE: 22 July 1953 RANGE: 300 Yards

FIRED FROM: Romney Creek B.R. SKY CONDITION: Bright Sun

WIND: 5-6 mph line of fire

CARTRIDGE: .30 Carbine

Semi-Automatic Dispersion

Target measurements are given in inches.

RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
Perrin	1	5.8	4.0	3.1	19.0	13.7	19.1
Perrin	2	5.8	3.9	3.4	20.2	9.9	20.2
Perrin	3	4.9	3.7	2.1	19.7	10.7	19.8
Perrin	4	5.2	4.4	2.4	20.1	8.1	21.7
Gustafson	1	7.2	5.8	3.1	29.3	14.1	30.4
Gustafson	2	10.4	7.9	4.5	30.4	24.0	35.7
Gustafson	3	4.8	2.7	2.9	9.7	18.8	18.9
Gustafson	4	7.5	6.0	3.5	29.7	20.4	31.7
Average		6.5	4.8	3.1	22.3	15.0	24.7

AUTOMATIC ACCURACY TEST

DATE: 4 August 1953 RANGE: 25 Yards

FIRED FROM: Position 20 SKY CONDITION: Hazy

CARTRIDGE: .30, .45, .224 Carbine: 14.3 grs. #4227, 41 gr. Sisk

Shot coordinates are given in inches from point of aim.

RIFLEMAN	CALIBER	1st SHOT	2nd SHOT	3rd SHOT
Perrin	.22	1.03, -3.06	.4, -2.37	7.56, -4.18
Steph	.22	.44, -1.0	1.8, -.75	15.6, 4.86
Perrin	.22	.7, -1.25	.82, -3.0	6.5, -2.5
Steph	.22	.18, -1.15	2.85, -2.8	11.65, -3.35
Perrin	.22	.86, -1.75	-.31, -.56	1.9, -.31
Steph	.22	.03, -2.82	-2.6, .48	13.06, 9.70
Perrin	.22	-.15, 2.18	-.65, -1.42	4.06, -2.12
Steph	.22	.03, -1.68	-2.23, 1.47	8.1, 8.05
Perrin	.22	.38, -.3.25	-3.86, -1.68	.03, 1.75
Steph	.22	-.1, -.75	-6.14, 4.91	11.36, 19.40
Perrin	.30	0, 2.18	-.25, 30.0	15.8, 72.65
Perrin	.30	-1.25, 3.12	1.12, 26.70	12.68, 61.0
Perrin	.30	-1, 1.77	-1.4, 27.27	18.4, 68.05
Perrin	.30	-.87, 2.06	2.65, 28.75	23.93, 73.9
Perrin	.30	.31, 3.00	-.06, 28.25	20.57, 69.0
Steph	.30	-.62, 3.94	3.9, 32.8	22.97, 69.87
Steph	.30	-1.7, 1.12	14.25, 2156	23.4, 59.05
Steph	.30	-1.0, 3.20	2.6, 35.70	45.31, 76.03
Steph	.30	-.06, 3.13	8.65, 32.10	43.5, 63.5
Steph	.30	-1.97, 3.35	10.0, 29.92	39.9, 55.8

AUTOMATIC ACCURACY TEST

(Cont'd)

RIFLEMAN	CALIBER	1st SHOT	2nd SHOT	3rd SHOT
Perrin	.45	.25, 7.12	1.25, 27.40	.37, 53.2
Perrin	.45	1.56, 5.80	8.5, 33.30	18.85, 75.44
Perrin	.45	4.0, 4.67	7.2, 29.50	15.56, 63.37
Perrin	.45	-1.34, 5.37	2.12, 22.86	5.7, 51.70
Perrin	.45	1.94, 9.0	10.5, 33.78	18.25, 59.20
Gustafson	.45	.96, 8.62	12.9, 29.50	37.68, 54.00
Gustafson	.45	.92, 7.17	12.47, 32.25	32.48, 61.31
Gustafson	.45	2.8, 7.72	16.5, 32.90	34.37, 62.09
Gustafson	.45	1.4, 6.90	16.2, 33.90	31.16, 61.40
Gustafson	.45	3.62, 7.85	14.96, 30.45	33.6, 54.62
Gustafson	.22	.55, .38	2.52, 4.8	19.77, 6.75
Gustafson	.22	-.1, -.81	.03, 1.37	17.37, 5.72
Gustafson	.22	.47, -.03	2.52, 1.75	14.18, 7.48
Gustafson	.22	.48, -1.18	2.55, 0	20.21, 4.5
Gustafson	.22	-.06, -.69	-4.7, 2.19	-5.44, 7.47
Gustafson	.30	-.56, 3.77	3.66, 36.90	37.47, 89.68
Gustafson	.30	-1.17, 4.00	8.26, 37.45	41.08, 88.2
Gustafson	.30	-.11, 3.64	5.87, 37.20	43.35, 88.25
Gustafson	.30	-.11, 3.25	2.82, 35.06	25.4, 86.0
Gustafson	.30	-.55, 2.97	2.37, 37.06	31.5, 88.8
Steph	.45	2.9, 7.16	15.0, 27.03	25.68, 54.72
Steph	.45	1.56, 6.08	8.3, 20.68	19.85, 43.34
Steph	.45	1.03, 2.00	4.5, 11.88	8.12, 26.36
Steph	.45	1.38, 8.25	6.08, 19.85	17.64, 40.75
Steph	.45	.37, 10.90	11.25, 26.47	22.18, 48.50

ACCURACY TEST

DATE: 3 August 1953 RANGE: 200 and 300 Yards

FIRED FROM: Romney Creek DIRECTION OF FIRE: S 39° W

WIND: Fishtailing wind from behind shooter - Velocity to 15 mph SKY CONDITION: Bright Sun

CARTRIDGE: .30, .224 Carbine: 14.3 grs. #4227, 41 gr. Sisk

Target measurements are given in inches.

RIFLEMAN	TYPE OF FIRE	POSITION	NO. OF ROUNDS	TYPE OF TARGET	CAL.	SCORE
		300 Yards				
Gustafson	Slow fire	Prone	6 shots	A Target	.22	26
Gustafson	Sustained	Standing to Prone	9 shots	A Target	.22	37
Perrin	Slow fire	Prone	6 shots	A Target	.30	25
Gustafson	Slow fire	Sitting	6 shots	A Target	.22	26
Perrin	Slow fire	Sitting	6 shots	A Target	.30	25
Perrin	Sustained	Standing to Prone	9 shots-	A Target	.30	40
Gustafson	Slow fire	Prone	6 shots	A Target	.30	27
Gustafson	Slow fire	Sitting	6 shots	A Target	.30	24
Gustafson	Sustained	Standing to Prone	9 shots	A Target	.30	36
Perrin	Slow fire	Prone	6 shots	A Target	.22	27
Perrin	Slow fire	Sitting	6 shots	A target	.22	29
Perrin	Sustained	Standing to Prone	9 shots	A Target	.22	37
		200 Yards				
Gustafson	Slow fire	Kneeling	6 shots	A Target	.30	28
Gustafson	Slow fire	Standing	6 shots	A Target	.30	25
Gustafson	Sustained	Standing to Sitting	9 shots	A Target	.30	38
Perrin	Slow fire	Kneeling	6 shots	A Target	.22	26
Perrin	Slow fire	Standing	6 shots	A Target	.22	24
Perrin	Sustained	Standing to sitting	9 shots	A Target	.22	44

.224 Carbine failed to extract on 10th round.

ACCURACY TEST (Cont'd)

RIFLEMAN	TYPE OF FIRE	POSITION	NO. OF ROUNDS	TYPE OF TARGET	CAL.	SCORE
Gustafson	Slow fire	Kneeling	6 shots	A target	.22	29
Gustafson	Slow fire	Standing	6 shots	A Target	.22	27
Gustafson	Sustained	Standing to Sitting	9 shots	A Target	.22	41
	.22 Carbine failed to eject on 129th round. .22 Carbine failed to extract on 132d round.					
Perrin	Slow fire	Kneeling	6 shots	A Target	.30	26
Perrin	Slow fire	Standing	6 shots	A Target	.30	27
Perrin	Sustained	Standing to Sitting	9 shots	A Target	.30	37

BURST FIRE ACCURACY TEST AT 200 YARDS

PRONE POSITION WITH BIPOD

17 July 1953 Romney Creek Range

ROUND NO.	WEAPON TYPE & NUMBER	TARGET NO.	COMPENSATOR	GUNNER	REMARKS
1-5	Caliber .30		Without	Perrin	5-shot burst, 3 hits
1	Caliber .224		With	Perrin	Conditioning round
2-6	Caliber .224	1	With	Perrin	5-shot burst, 5 hits
7-11	Caliber .224	2	With	Perrin	5-shot burst, 5 hits
12-16	Caliber .224	3	With	Perrin	5-shot burst, 5 hits
17-21	Caliber .224	4	With	Perrin	5-shot burst, 5 hits
22-26	Caliber .224	5	With	Perrin	5-shot burst, 5 hits
6-8	Caliber .30		With	Gustafson	3-shot conditioning burst
9-13	Caliber .30	6	With	Gustafson	5-shot burst, 5 hits
14-18	Caliber .30	7	With	Gustafson	5-shot burst, 3 hits
19-23	Caliber .30	8	With	Gustafson	5-shot burst, 4 hits
24-28	Caliber .30	9	With	Gustafson	5-shot burst, 5 hits
29-33	Caliber .30	10	With	Gustafson	5-shot burst, 4 hits
34-38	Caliber .30	11	With	Perrin	5-shot burst, 5 hits
39-43	Caliber .30	12	With	Perrin	5-shot burst, 5 hits
44-48	Caliber .30	13	With	Perrin	5-shot burst, 5 hits
49-53	Caliber .30	14	With	Perrin	5-shot burst, 5 hits
54-58	Caliber .30	15	With	Perrin	5-shot burst, 4 hits
27-31	Caliber .224	16	With	Gustafson	5-shot burst, 5 hits
32-36	Caliber .224	17	With	Gustafson	5-shot burst, 4 hits
37-41	Caliber .224	18	With	Gustafson	5-shot burst, 5 hits
42-46	Caliber .224	19	With	Gustafson	5-shot burst, 5 hits
47-51	Caliber .224	20	With	Gustafson	5-shot burst, 5 hits

ACCURACY TEST

DATE: 21 July 1953 RANGE: 200 Yards

FIRED FROM: Romney Creek SKY CONDITION: Bright Sun

WIND: 0

CARTRIDGE: .30 Carbine

Target measurements are given in inches.

				Burst Fire Accuracy			
RIFLEMAN	TARGET NO.	MR	MVD	MHD	EVD	EHD	ES
Gustafson	6 - *5 hits	10.2	6.3	7.2	22.0	22.3	28.1
Gustafson	7 - 3 hits	3 rds. ES - 1.6". Other 2 rds missed 8' x 8' Target.					
Gustafson	8 - 4 hits	4 rds. ES - 5.5". Other rd. missed 8' x 8' Target.					
Gustafson	9 - 5 hits	14.0	10.9	7.5	26.8	28.9	35.5
Gustafson	10 - 4 hits	4 rds. ES - 49.2". Other rd. missed 8' x 8' Target.					
Perrin	11 - 5 hits	10.8	8.2	5.1	22.3	25.9	27.7
Perrin	12 - 5 hits	8.1	6.0	4.4	19.2	21.3	27.0
Perrin	13 - 5 hits	7.9	3.2	6.1	13.3	23.1	23.8
Perrin	14 - 5 hits	7.8	2.5	6.4	24.3	11.2	24.9
Perrin	15 - 4 hits	4 rds. ES - 20.3". Other rd. missed 8' x 8' Target.					

* 8' x 8' target. The number of hits on the 8' x 8' target are recorded above. The remaining rounds missed the target.

ACCURACY TEST

DATE: 21 July 1953 RANGE: 200 Yards

FIRED FROM: Romney Creek SKY CONDITION: Bright Sun

WIND: 0

CARTRIDGE: .224 Carbine, 41 gr. Sisk, 14.3 grs. #4227

Target measurements are given in inches.

			Burst Fire Accuracy					
RIFLEMAN	TARGET NO.		MR	MVD	MHD	EVD	EHD	ES
Perrin *(5 hits)	1		7.1	2.9	5.4	11.2	17.2	17.2
Perrin	5 hits	2	3.3	1.7	2.1	5.4	9.0	9.0
Perrin	5 hits	3	4.2	3.0	2.2	12.3	6.4	12.8
Perrin	5 hits	4	5.9	3.2	3.8	12.3	13.1	13.6
Perrin	5 hits	5	5.9	4.3	3.4	15.4	10.3	17.4
Gustafson	5 hits	16	11.9	8.7	7.5	28.4	24.4	37.4
Gustafson	5 hits	17	10.4	6.9	7.0	16.9	24.1	29.4
Gustafson	5 hits	18	8.2	3.7	5.6	13.2	22.4	22.4
Gustafson	5 hits	19	7.7	5.6	5.2	23.2	12.3	23.8
Gustafson	5 hits	20	7.1	3.8	5.1	12.4	16.2	17.4
Mean (Perrin)			5.2	3.0	3.4	11.3	11.2	14.0
Mean (Gustafson)			9.1	5.7	6.1	18.8	19.9	26.1
Mean (Total)			7.2	4.4	4.7	15.1	15.5	20.0

* 8' x 8' Target

BURST FIRE ACCURACY TEST AT 300 YARDS

PRONE POSITION WITH BIPOD AND COMPENSATOR

17 August 1953

ROUND NUMBER	WEAPON CALIBER	TARGET NUMBER	GUNNER	REMARKS
1-11	Cal. .22	--	Perrin	Sighting shots
12-16	Cal. .22	1	Perrin	5 hits
17-21	Cal. .22	2	Perrin	5 hits
22-26	Cal. .22	3	Perrin	5 hits
27-31	Cal. .22	4	Perrin	5 hits
32-36	Cal. .22	5	Perrin	5 hits
37-46	Cal. .22	--	Gustafson	Sighting shots
47-51	Cal. .22	6	Gustafson	5 hits
52-56	Cal. .22	7	Gustafson	5 hits
57-61	Cal. .22	8	Gustafson	5 hits
62-66	Cal. .22	9	Gustafson	5 hits
67-71	Cal. .22	10	Gustafson	5 hits

BURST FIRE ACCURACY TEST AT 300 YARDS

Measurements in Inches

TARGET NUMBER	GUNNER	MEAN RADIUS	MEAN VERTICAL DEVIATION	MEAN HORIZONTAL DEVIATION	EXTREME VERTICAL DEVIATION	EXTREME HORIZONTAL DEVIATION	EXTREME SPREAD
1	Perrin	10.47	7.11	6.52	21.35	21.95	28.50
2	Perrin	10.51	7.54	7.22	25.70	24.50	35.48
3	Perrin	14.26	12.61	5.95	34.55	17.96	38.83
4	Perrin	9.65	7.60	5.20	25.55	15.85	29.56
5	Perrin	10.29	7.13	4.18	24.82	25.45	33.06
6	Gustafson	22.13	18.56	10.14	57.05	28.06	57.25
7	Gustafson	16.34	14.59	6.37	41.68	26.50	43.88
8	Gustafson	12.71	8.26	8.74	29.43	25.58	35.19
9	Gustafson	13.41	8.73	9.71	24.79	35.60	42.81
10	Gustafson	12.60	9.50	8.07	27.59	27.03	38.60
1-10	Average	13.24	10.14	7.21	31.25	24.85	38.31

AMMUNITION PROGRAM (PENETRATION PHASE)

F-8 Summary:

M1 Helmet Penetration - .224 Carbine

Using the 41 gr. Sisk Super-Lovell bullet and 14.7 grs. #2400 powder, complete penetration was obtained at 350 yards on three rounds. At 400 yards the bullet only dented the helmet and there was no penetration.

Using the 35 gr. NRA Full-Patch bullet and 15.8 grs. #4227, identical results were obtained.

M1 Helmet Penetration - .30 Carbine

Using the standard .30 carbine, complete penetration was obtained at 400 yards on the front side of helmet.

Body Armor Penetration - .224 Carbine

With the 41 gr. Sisk bullet and 14.7 grs. #2400, complete penetration was obtained at 250 yards. The bullet penetrated the steel plates and the nylon backing. At 300 yards, the bullet penetrated the steel plates but failed to go through the nylon backing.

Using the 35 gr. Full-Patch bullet and 15.8 grs. #4227, there was partial penetration at 300 yards.

Body Armor Penetration - .30 Carbine

With the standard .30 carbine ball, complete penetration of both the steel plates and the nylon backing was obtained at 200 yards. When the armor was moved to 250 yards, the .30 carbine ball penetrated the steel plates but failed to pierce the nylon backing.

Test of: M1 Helmet Penetration - .224 Carbine 41 gr. Sisk, 14.7 gr. #2400

23 June 1953

ROUND	TIME	REMARKS
1	1346	At 350 yards. Dented helmet. Angle of obliquity: 0-8°
2	1348	Skinned helmet. Angle of obliquity: 45-60°.
3	1350	Barely creased helmet. Angle of obliquity: 85°. Fired first three shots at top of helmets.
4	1421	Missed helmets.
5	1429	Missed helmets.
6	1434	Missed helmets.
7	1438	Missed helmets.
8	1442	Missed helmets.
9	1445	Missed helmets.
10	1445	Dented helmet. Angle of obliquity: 10°. Hit helmet on top of crown (thickest section)
11	1449	Missed helmets. (35 gr. WRA Full-Patch
12	1450	Missed helmets. (15.8 grs. #4227
13	1453	Missed helmets.
14	1453	Dented helmet. Angle of obliquity: 10°.

Test of: M1 Helmet Penetration - .22L Carbine

24 June 1953

ROUND	TIME	REMARKS
1	1031	At 400 yards. Missed helmets.
2	1034	Missed helmets.
3	1037	Missed helmets.
4	1040	Missed helmets.
5	1042	Missed helmets.
6	1046	Couldn't find bullet hole.
7	1050	Missed helmets.
8	1052	Creased helmet, high angle of obliquity.
9	1054	Creased helmet, high angle of obliquity.
10	1054	Good hit, dented helmet. Angle of obliquity: 5°.
11	1056	Hit on rim.
12	1056	Creased helmet. High angle of obliquity.
13	1058	Creased helmet. High angle of obliquity. (35 gr. WRA
14	1059	Missed helmet. (Full-Patch.
15	1100	Good hit. Dented Helmet. Angle of obliquity: 0°. (15.8 gr. #4227
16	1133	At 350 yards. Couldn't find hole.
17	1139	Couldn't find hole.
18	1145	Missed helmets.
19	1146	Missed helmets.
20	1154	Missed helmets.
21	1154	Missed helmets.
22	1155	Creased helmet, high angle of obliquity. (35 gr. Full-
23	1155	Complete penetration, bullet lodged in helmet. Angle of obliquity: 0°. (Patch. (15.8 grs. #4227

Test of: M1 Helmet Penetration - .224 Carbine (Cont'd) 24 June 1953

ROUND	TIME	REMARKS
24	1234)	
25	1234)	
26	1235)	Complete penetration on three rounds.
27	1235)	41 gr. Sisk 14.7 grs. #2400
28	1235)	

Test of: M1 Helmet Penetration - .30 Carbine

23 June 1953

ROUNI	TIME	REMARKS
1	1500	At 350 yards. Missed helmets.
2	1502	Missed helmets.
3	1507	Dented helmet. Angle of obliquity: 40°-45°.
4	1509	Missed helmet.
5	1509	Missed helmet.
6	1509	Missed helmet.
7	1510	Dented helmet. Angle of obliquity: 60°.
8	1512	Missed helmet.
9	1512	Missed helmet.
10	1513	Missed helmet.
11	1513	Complete both sides. Angle of obliquity: 0°. At 375 yards.
12	1521	Missed helmets.
13	1528	Missed helmets.
14	1530	Couldn't find hole in target board.
15	1534	Hitting at high angle of obliquity, just creases.
16	1535	
17	1537	Missed helmets.
18	1537	Missed helmets.
19	1538	Missed helmets.
20	1538	Missed helmets.
21	1538	Missed helmets.
22	1541	Missed helmets.
23	1542	Missed helmets.
24	1544	Grased helmet - high angle of obliquity.

Test of: M1 Helmet Penetration - .30 Carbine (Cont'd) 23 June 1953

ROUND	TIME	REMARKS
25	1545	Missed helmet.
26	1546	Grazed helmet - high angle of obliquity.

Test of: M1 Helmet Penetration - .30 Carbine

24 June 1953

ROUND	TIME	REMARKS
1	0940	At 375 yards. Couldn't find holes.
2	0940	
3	0945	Missed helmets.
4	0945	Creased top of helmet, high angle of obliquity.
5	0952	
6	0952	Missed helmets.
7	0953	
8	0953	Creased helmet, high angle of obliquity.
9	0953	Penetrated front of helmet, dented back.
10	1004	At 400 yards. Missed helmets.
11	1010	Missed helmets.
12	1010	Missed helmets.
13	1014	Missed helmets.
14	1014	Hit front of helmet, large bulge, no penetration. Angle of obliquity: 0°.
15	1016	Missed helmets.
16	1016	Missed helmets.
17	1017	Hit low on front of helmet, penetration on front, none on back. Angle of obliquity: 0°.
18	1017	Creased helmet, high angle of obliquity.

Test of: Body Armor Penetration - .224 Carbine

41 gr. Sisk, 14.7 gr. #2400

23 June 1953

ROUND	TIME	REMARKS
1	1132	Complete penetration at 200 yards.
2	1248	Complete penetration at 250 yards.
3	1254	Missed armor. Target at 300 yards.
4	1257	Missed armor.
5	1300	Partial penetration at 300 yards. Bulge on back of plate.
6	1303	Missed armor.
7	1305	Partial penetration at 300 yards.
8	1310	Hit fabric - missed plate.
9	1313	Hit where two plates overlap - double thickness.
10	1316	Hit where two plates overlap - double thickness.
11	1319	Missed armor.
12	1321	Partial penetration at 300 yards.
13	1325	Hit fabric - missed plate. 35 gr. WRA Full-Patch, 15.8 grs. #4227.
14	1327	Partial penetration at 300 yards. 35 gr. WRA Full-Patch, 15.8 grs. #4227.
15	1330	Partial penetration at 300 yards. 35 gr. WRA Full-Patch, 15.8 grs. #4227.

Using Carbine.

Test of: Body Armor Penetration - .30 Carbine

23 June 1953

ROUND	TIME	REMARKS
1	1022	300 yards. No penetration.)
2	1025	No penetration.) Lost. Body armor
3	1025	No penetration.) turned in reverse.
4	1030	)
5	1030	) Two rounds missed armor. About 50% penetration
6	1031	) on the one hit.
7	1034	)
8	1034	)
9	1035	) Almost penetrated.
10	1035	)
11	1041	Locator. Target moved to 280 yards.
12	1045	) Penetrated steel plate but failed to penetrate
13	1046	) nylon backing.
14	1052	Locator. Target moved to 250 yards.
15	1055	Locator.
16	1057	Locator. Hit top edge of a plate. Complete penetration on the edge.
17	1059	) Hit top edge of fabric and plate.
18	1100	)
19	1102	Missed armor.
20	1105	Penetrated plate but not nylon.
21	1119	Missed armor. Target moved to 200 yards.
22	1123	Complete penetration.
23	1124	) Complete penetration.
24	1124	)

CALIBER .224 CARBINE LEAD-CORE BALL

CALIBER .30 CARBINE LEAD-CORE BALL

ON

1/4" MILD STEEL PLATE - 50 YARDS RANGE

SHOT NO.	WEAPON	RESULT
1	.224 Carbine Mann Barrel	Complete perforation
2	.224 Carbine Mann Barrel	Complete perforation
3	.224 Carbine Mann Barrel	Complete perforation
4	.224 Carbine Mann Barrel	Complete perforation
5	.224 Carbine Mann Barrel	Complete perforation
6	.30 Carbine Mann Barrel	.080-inch indentation
7	.30 Carbine Mann Barrel	.090-inch indentation
8	.30 Carbine Mann Barrel	.070-inch indentation
9	.30 Carbine Mann Barrel	.070-inch indentation
10	.30 Carbine Mann Barrel	.080-inch indentation

Plate Type: SAE 1020, annealed.

CALIBER .224 CARBINE A.P. BULLET

CALIBER .30 CARBINE A.P. BULLET

ON

1/4-INCH HOMOGENEOUS PLATE - 50 YARDS

SHOT NO.	WEAPON	RESULT
1	.224 Carbine Mann Barrel	Complete Penetration
2	.224 Carbine Mann Barrel	Complete Perforation
3	.224 Carbine Mann Barrel	Complete Penetration
4	.224 Carbine Mann Barrel	Complete Perforation
5	.224 Carbine Mann Barrel	Complete Perforation
6	224 Carbine Mann Barrel	Complete Perforation
7	.30 Carbine Mann Barrel	.090-inch penetration
8	.30 Carbine Mann Barrel	.100-inch penetration
9	.30 Carbine Mann Barrel	.090-inch penetration
10	.30 Carbine Mann Barrel	.080-inch penetration
11	.30 Carbine Mann Barrel	.090-inch penetration

Plate Type: Homogeneous Plate, Hardness Brinell 375

15.8 grs. #4227

CALIBER .224 CARBINE A.P. BULLET

CALIBER .30 CARBINE A.P. BULLET

ON

1/4-INCH FACE-HARDENED PLATE - 50 YARDS

SHOT NO.	WEAPON	RESULT
1	.224 Carbine Mann Barrel	Complete Perforation
2	.224 Carbine Mann Barrel	.070" Penetration
3	.224 Carbine Mann Barrel	Complete Perforation
4	.224 Carbine Mann Barrel	Complete Perforation
5	.224 Carbine Mann Barrel	Complete Perforation
6	.30 Carbine Mann Barrel	.020" Penetration
7	.30 Carbine Mann Barrel	.010" Penetration
8	.30 Carbine Mann Barrel	.080" Penetration
9	.30 Carbine Mann Barrel	.020" Penetration
10	.30 Carbine Mann Barrel	.020" Penetration

Plate Specifications - Face Hardness Brinell 600
Rear Hardness Brinell 430

15.8 grs. #4227

RECOIL-PENDULUM MEASUREMENTS

K.E. = P.E.

$1/2\ M_p V_p^2 = M_p g h$

$1/2\ V_p^2 = gh$

$V_p = \sqrt{2gh}$

$M_p = M_b V_b + M_o \times 4800 = M_p V_p$

$M_g = M_b V_b + M_o \times 4800 = M_g V_g$

$M_p V_p = M_g V_g$

$V_g = \frac{M_p}{M_g} V_p$

$\cos \theta = \frac{S - h}{S}$

$S \cos \theta = S - h$

$h = S - S \cos \theta = S(1 - \cos \theta)$

$\sin 1/2\ \theta = \frac{1/2\ l}{S}$

$1/2\ \theta = \sin^{-1} \frac{1/2\ l}{S}$

$\theta = 2 \sin^{-1} \frac{l}{2S}$

Method for reducing displacement of ballistic pendulum to foot-lbs. of free recoil of weapon

(5) K.E. (ft-lbs) = $1/2\ M_g V_g^2$

(4) $V_g = \frac{M_p}{M_g} V_p$

(3) $V_p = 2gh$

(2) $h = S(1 - \cos \theta)$

(1) $\theta = \sin^{-1} \frac{l}{2S}$

l = length of arc through which pendulum swings, or displacement
M_g = Mass of weapon
V_g = Velocity of weapon in recoil
M_p = Mass of pendulum including weapon
V_p = Velocity of pendulum in recoil including weapon
g = gravity (32.1549 ft/sec^2 at Baltimore, Md.)
h = Vertical distance pendulum rises in ft.
S = Length of pendulum, from pt. of suspension to point of measurement
θ = Angle through which pendulum swings

Test of: Free Recoil of .30 Carbine

10 July 1953

Velocity at 45 feet. 1st Screen - 20' from Muzzle. 1st to 2nd: 50'.

ROUND	VELOCITY	DISPLACEMENT (inches)	REMARKS
		.30 Carbine Without Compensator	
1	1926	4.78	
2	1939	----	Pendulum measurement lost.
3	1978	4.92	
4	1937	4.81	
5	1969	----	Pendulum measurement lost.
6	1925	4.78	
7	1938	4.83	
		.30 Carbine With Compensator	
8	1943	4.51	
9	1955	4.55	
10	1957	4.53	
11	1986	4.56	
12	1963	4.57	

Weight of pendulum without gun) 45.69 lbs.
) 45 lbs. 11 oz.

Weight of .30 Carbine weapon* 4.52 lbs.

Weight of .224 Carbine weapon* 4.71 lbs.

Weight of Compensator for .30 Carbine .3 lb.

Weight of Compensator for .224 Carbine .05 lb.

** Weight of M2 Carbine, 15 rd. loaded magazine and sling = 6.10 lbs.

** Weight of .224 Carbine, 15 rd. loaded magazine and sling = 6.30 lbs.

* Weapons used in actual test with rear of stock cut off.
** Complete weapons upon which calculations were based.

Test of: Free Recoil of .224 Carbine

13 July 1953

Velocity at 45 feet. 20' to 1st Screen - 50' between

41 gr. Sisk Blend Load

ROUND	VELOCITY	DISPLACEMENT (inches)	REMARKS
	.224 Carbine With Compensator		
1	2870		Pendulum measurement lost.
2	2907	2.32	
3	2957	2.35	
4	2917	2.31	
5	2884	2.31	
6	2900	2.31	
		35 gr. WRA 15.8 grs. #4227	
7	3019	2.01	
8	3019	2.00	
9	3036	2.02	
10	2998	1.98	
11	3028	2.00	
	.224 Carbine Without Compensator		
		41 gr. Sisk Blend Load	
12	2964	3.58	
13	2875	3.51	
14	2936	3.56	
15	2927	3.57	
16	2941	3.57	
		35 gr. WRA 15.8 grs. #4227	
17	3041	3.06	
18	3053	3.09	
19	3041	3.05	
20	3041	3.09	
21	3019	3.08	

CHRONOGRAPH VELOCITY REPORT

10 July 1953 Page 1

Proof Director: Mr. Steph Program: Caliber .30

Gun to 1st Coil: 20.00' 1st to 2nd Coil: 50.00'

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VEL.	REMARKS
1	1408	2596	1926	Without Compensator
2	1412	2578	1939	
3	1416	2528	1978	
4	1424	2581	1937	
5	1428	2540	1969	
6	1502	2597	1925	
7	1505	2580	1938	
8	1554	2574	1943	With Compensator
9	1556	2557	1955	
10	1600	2555	1957	
11	1602	2518	1986	
12	1605	2547	1963	

CHRONOGRAPH VELOCITY REPORT

13 July 1953

Proof Director: Steph

Program: Caliber .22

Gun to 1st Coil: 20.00'

1st to 2nd Coil: 50.00'

ROUND NO.	HOUR	COIL TIME	INSTRUMENT VEL.	PROJECTILE
1	0922	1742	2870	41 gr. Bullet with Compensator
2		1720	2907	
3		1691	2957	
4	0931	1714	2917	
5		1734	2884	
6	0942	1724	2900	
7	0952	1656	3019	35 gr. with Compensator
8		1656	3019	
9	0957	1647	3036	
10		1668	2998	
11		1651	3028	
12	1038	1687	2964	41 gr. without Compensator
13		1739	2875	
14		1703	2936	
15	1045	1708	2927	
16		1700	2941	
17		1644	3041	35 gr. without Compensator
18		1638	3053	
19		1644	3041	
20	1104	1644	3041	
21		1656	3019	

.224 CARBINE WITH COMPENSATOR, 41 GR. SISK, BLEND LOAD

15 ROUND LOADED MAGAZINE AND SLING

ROUND	$\frac{1}{(in)}$	$\frac{1}{28}$	1/2 θ	θ	cos θ	1-cos θ	S(1-cos θ)	h(ft)	2 gh	$\sqrt{2gh}=V_p$
2	2.32	.01257	0°43'	1°26'	.99969	.00031	.02860	.00238	.15306	.39123
3	2.35	.01274	0°44'	1°28'	.99967	.00033	.03044	.00254	.16335	.40416
4	2.31	.01252	0°43'	1°26'	.99969	.00031	.02860	.00238	.15306	.39123
5	2.31	.01252	0°43'	1°26'	.99969	.00031	.02860	.00238	.15306	.39123
6	2.31	.01252	0°43'	1°26'	.99969	.00031	.02860	.00238	.15306	.39123

Wt. of pendulum with .224 and comp = 52.04 lbs.

Wt. of weapon and comp = 6.35

$\frac{M_p}{M_g}$ = 8.19528

$\frac{M_p}{M_g} V_p = V_g$	V_g^2	$1/2\ MV_g^2$	K.E. (ft-lbs)
3.20624	10.27997	32.63890	1.02
3.31220	10.97067	34.83188	1.09
3.20624	10.27997	32.63890	1.02
3.20624	10.27997	32.63890	1.02
3.20624	10.27997	32.63890	1.02
		Mean	1.034

.224 CARBINE WITHOUT COMPENSATOR, 41 GR. SISK, DUPLEX LOAD

WITH 15 ROUND LOADED MAGAZINE AND SLING

ROUND	l (in)	$\frac{l}{28}$	1/2 θ	θ	cos θ	1-cos θ	S(1-cos θ)	h(ft)	2gh	$\sqrt{2gh} = V_p$
12	3.58	.01940	1°07'	2°14'	.99924	.00076	.07011	.00584	.37557	.61283
13	3.51	.01902	1°05'	2°10'	.99929	.00071	.06550	.00546	.35113	.59256
14	3.56	.01930	1°06'	2°12'	.99926	.00074	.06827	.00569	.36592	.60491
15	3.57	.01935	1°07'	2°14'	.99924	.00076	.07011	.00584	.37557	.61283
16	3.57	.01935	1°07'	2°14'	.99924	.00076	.07011	.00584	.37557	.61283

Mass of pendulum with weapon = 51.99 lbs.

Wt. of weapon = 6.30 lbs.

$\frac{M_p}{M_g} = 8.25238$

$\frac{M_p}{M_g} V_p = V_g$	V_g^2	1/2 MV^2	K.E. (ft. lbs.)
5.05731	25.57638	80.56559	2.52
4.89003	23.91239	75.32403	2.35
4.99195	24.91956	78.49661	2.45
5.05731	25.57638	80.56559	2.52
5.05731	25.57638	80.56559	2.52
		Mean	2.472

.224 CARBINE WITHOUT COMPENSATOR, 35 GR. WRA, 15.8 GRS. #4198

WITH 15 ROUND LOADED MAGAZINE AND SLING

ROUND	l (in)	$\frac{l}{2S}$	1/2 θ	θ	cos θ	1-cos θ	S(1-cos θ)	h(ft)	2gh	$\sqrt{2gh} = V_p$
17	3.06	.01659	0°57'	1°54'	.99945	.00055	.05074	.00423	.27203	.52156
18	3.09	.01675	0°58'	1°56'	.99943	.00057	.05258	.00438	.28168	.53073
19	3.05	.01653	0°57'	1°54'	.99945	.00055	.05074	.00423	.27203	.52156
20	3.09	.01675	0°58'	1°56'	.99943	.00057	.05258	.00438	.28168	.53073
21	3.08	.01669	0°57'	1°54'	.99945	.00055	.05074	.00423	.27203	.52156

Wt. of pendulum with .224 = 51.99 lbs.

Wt. of weapon = 6.30 lbs.

$\frac{M_p}{M_g}$ = 8.25238

$V_g = \frac{M_p}{M_g} V_p$	V_g^2	1/2 MV^2	K.E. (ft.-lbs.)
4.30411	18.52536	58.35488	1.82
4.37979	19.18256	60.42506	1.89
4.30411	18.52536	58.35488	1.82
4.37979	19.18256	60.42506	1.89
4.30411	18.52536	58.35488	1.82
		Mean	1.848

.224 CARBINE WITH COMPENSATOR, 35 GR. WRA, 15.8 GRS. #4198

15 ROUND LOADED MAGAZINE AND SLING

ROUND	$\frac{1}{}$ (in)	$\frac{1}{2S}$	1/2 θ	θ	cos θ	1-cos θ	S(1-cos θ)	h(ft)	2gh	$\sqrt{2gh}=V_p$
7	2.01	.01089	0°37'	1°14'	.99977	.00023	.02122	.00177	.11383	.33738
8	2.00	.01084	0°37'	1°14'	.99977	.00023	.02122	.00177	.11383	.33738
9	2.02	.01094	0°38'	1°16'	.99976	.00024	.02214	.00185	.11897	.34492
10	1.98	.01073	0°37'	1°14'	.99977	.00023	.02122	.00177	.11383	.33738
11	2.00	.01084	0°37'	1°14'	.99977	.00023	.02122	.00177	.11383	.33738

Wt. of pendulum with .224 and comp = 52.04 lbs.

Wt. of weapon and comp = 6.35 lbs.

$\frac{M_p}{M_g}$ = 8.19528

$V_g = \frac{M_p}{M_g} V_p$	V_g^2	1/2 MV^2	K.E. (ft.-lbs.)
2.76492	7.64478	24.27218	.76
2.76492	7.64478	24.27218	.76
2.82672	7.99035	25.36936	.79
2.76492	7.64478	24.27218	.76
2.76492	7.64478	24.27218	.76
		Mean	.766

$S = 92.25"$
$2S = 184.50$

$\theta = 2 \sin^{-1} \frac{l}{2S}$ $\qquad$ $h = S(1-\cos \theta)$

.30 CARBINE WITHOUT COMPENSATOR, WITH 15 ROUND

LOADED MAGAZINE AND SLING

ROUND	l (in)	$\frac{l}{2S}$	$\frac{1}{2}\theta$ $\sin^{-1} \frac{l}{2S}$	θ $2 \sin^{-1} \frac{l}{2S}$	$\cos \theta$	$1-\cos \theta$	h, in $S(1-\cos \theta)$	h, ft.
1	4.78	.02591	1°29'	2°58'	.99866	.00134	.1236	.0103
3	4.92	.02667	1°32'	3°04'	.99857	.00143	.1319	.0110
4	4.81	.02607	1°30'	3°00'	.99863	.00137	.1264	.0105
6	4.78	.02591	1°29'	2°58'	.99866	.00134	.1236	.0103
7	4.83	.02618	1°30'	3°00'	.99863	.00137	.1264	.0105

$V_p = 2gh$ $\qquad$ $g = 32.1549$ ft/sec^2 $\qquad$ $2g = 64.3098$

$2gh$	V_p $2gh$ fps		$\frac{M_p}{M_g} V_p = V_g$	V_g^2	lb-ft^2/sec^2 $1/2\ MV^2$	K.E. ft-lbs
.6592	.81191	Wt. of pendulum with .30 = 51.79 lbs.	6.89325	47.51689	144.92651	4.53
.7040	.83905	Wt. of gun = 6.10	7.12367	50.74667	154.77734	4.84
.6720	.81976		6.95989	48.44007	147.74221	4.62
.6592	.81191	$\frac{M_p}{M_g} = 8.49016$	6.89325	47.51689	144.92651	4.53
.6720	.81976		6.95989	48.44007	147.74221	4.62
					Mean	4.628

S = 92.25" $\quad$ g = 32.1549 ft/sec^2
2S = 184.50 $\quad$ 2g = 64.3098 ft/sec^2

.30 CARBINE WITH COMPENSATOR, 15 ROUND LOADED MAGAZINE AND SLING

ROUND	l (in)	$\frac{l}{2S}$	$\sin^{-1}\frac{l}{2S}$ = 1/2 θ	θ	cos θ	1-cos θ	h, in S(1-cos θ)	h, ft	2gh	$\sqrt{2gh}=V_p$
8	4.51	.02444	1°24'	2°48'	.99881	.00119	.10978	.00915	.58843	.76709
9	4.55	.02466	1°25'	2°50'	.99878	.00122	.11255	.00938	.60322	.77667
10	4.53	.02455	1°24'	2°48'	.99881	.00119	.10978	.00915	.58843	.76709
11	4.56	.02472	1°25'	2°50'	.99878	.00122	.11255	.00938	.60322	.77667
12	4.57	.02477	1°25'	2°50'	.99878	.00122	.11255	.00938	.60322	.77667

Wt. of pendulum with .30 and comp = 52.09 lbs.

Wt. of weapon and comp = 6.40

$\frac{M_p}{M_g}$ = 8.13906

$V_g = \frac{M_p}{M_g} V_p$	V_g^2	1/2 MV^2	K.E. (ft.-lbs.)
6.24339	38.97992	124.73574	3.90
6.32136	39.95959	127.87069	3.99
6.24339	38.97992	124.73574	3.90
6.32136	39.95959	127.87069	3.99
6.32136	39.95959	127.87069	3.99
		Mean	3.954

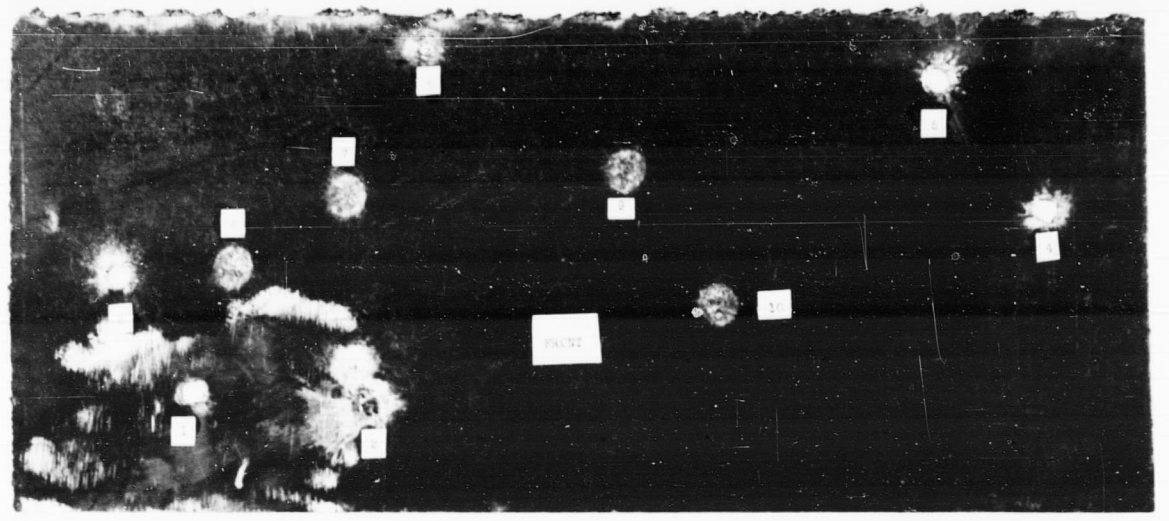
WEIGHT OF BULLETS USED IN RECOIL TEST

41 Gr. Sisk		35 Gr. W.R.A.		.30 Carbine Ball	
	Weight, grs.		Weight, grs.		Weight, grs.
1	41.095	1	34.198	1	109.530
2	41.160	2	34.192	2	109.215
3	41.200	3	34.155	3	109.497
4	41.200	4	34.092	4	109.651
5	41.200	5	34.190	5	109.733
Mean	41.171	Mean	34.165	Mean	109.525

APPENDIX C

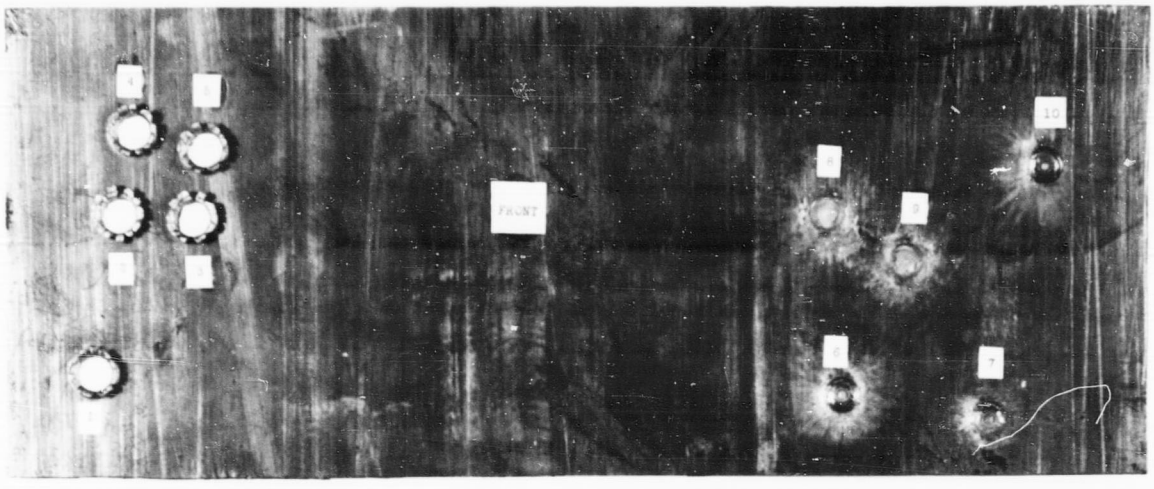
Aberdeen Proving Ground
Photographs Numbers

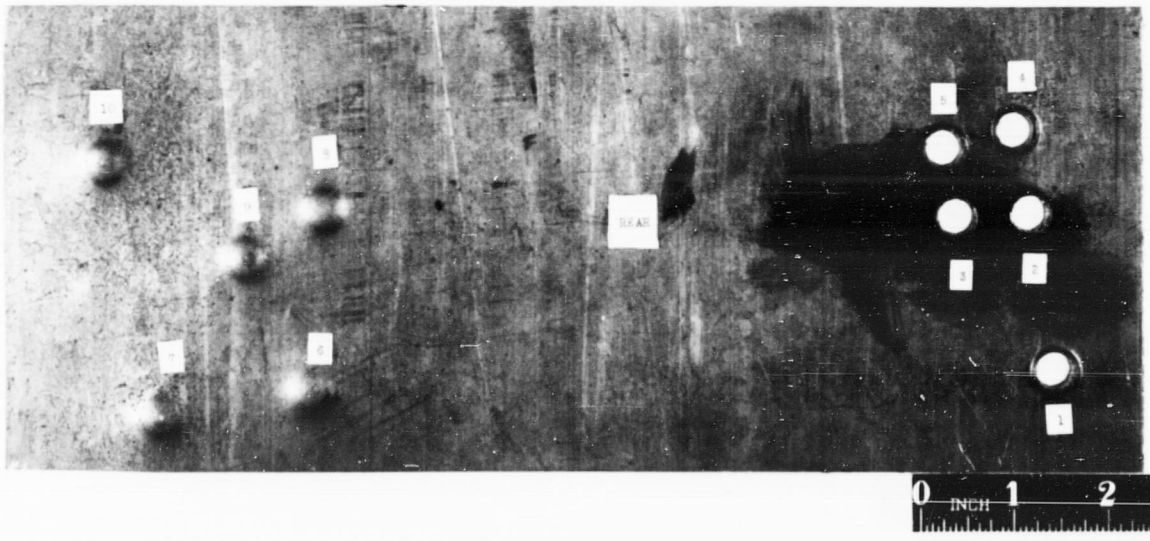
A90837
A90838
A90839
A90925
A90926
A91616
A91617



A90837 CONFIDENTIAL ABERDEEN PROVING GROUND 6 July 1953

Project No. TS1-2. Test of .224 Carbine Ammunition.
Illustrating penetration performance of Ctg., A.P., Cal. .30 Carbine, Lot No. FA-X30-1131, and Ctg., A.P., Cal. .224 (experimental), no lot, against ¼-inch face hardened armor plate (Brinell Hardness-Face 600, Rear 430) at a range of 50 yards. Numbers 1 through 5, Cal. .224. Numbers 6 through 10, Cal. .30 Carbine.

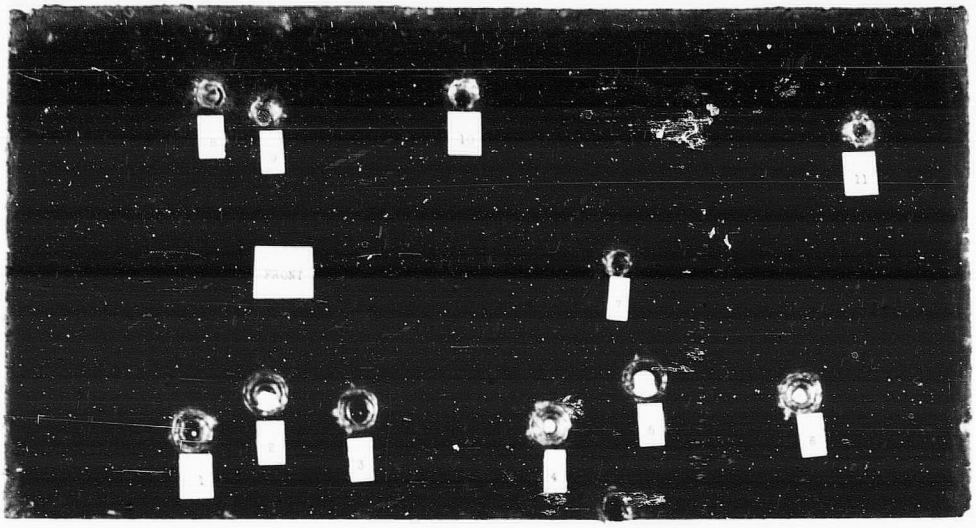


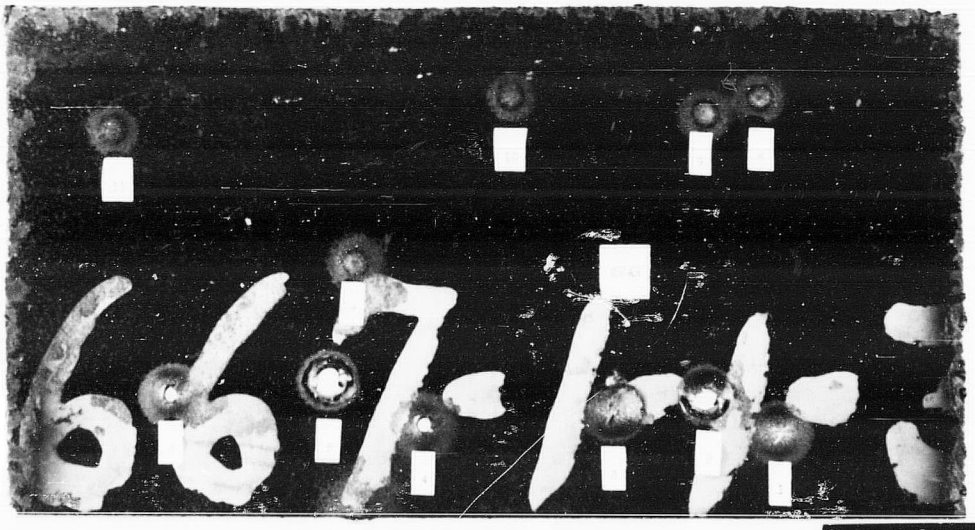


A90838 CONFIDENTIAL — ABERDEEN PROVING GROUND — 6 July 1953

Project No. TS1-2. Test of .224 Carbine Ammunition.
Illustrating penetration performance of Ctg., Ball, Cal. .30 Carbine, M1, Lot No. 6602, and Ctg., Ball, Cal. .224 (experimental), no lot, against ¼-inch mild steel plate (SAE-1020) at a range of 50 yards. Numbers 1 through 5, Cal. .224. Numbers 6 through 10, Cal. .30 Carbine.

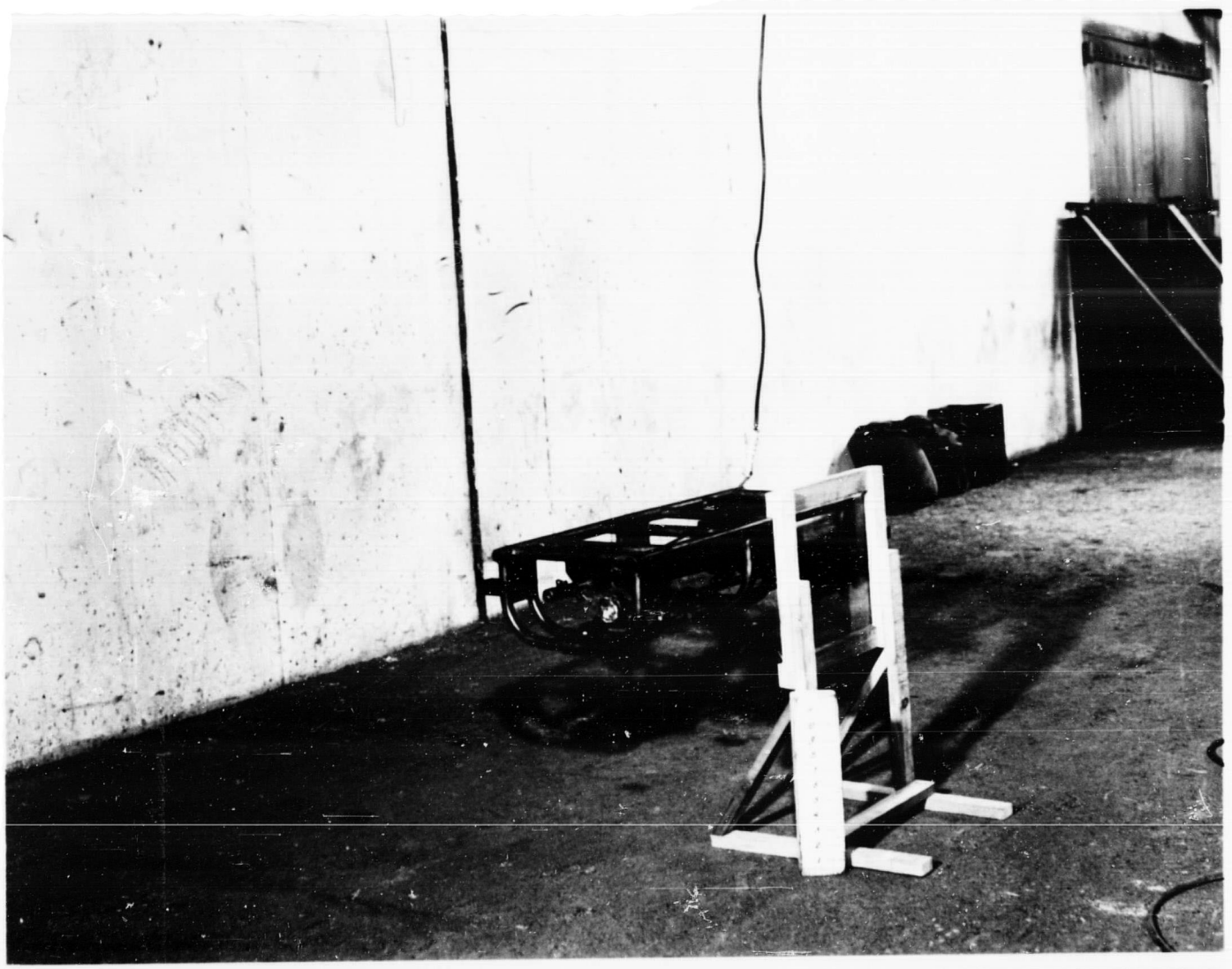
Security Information - CONFIDENTIAL





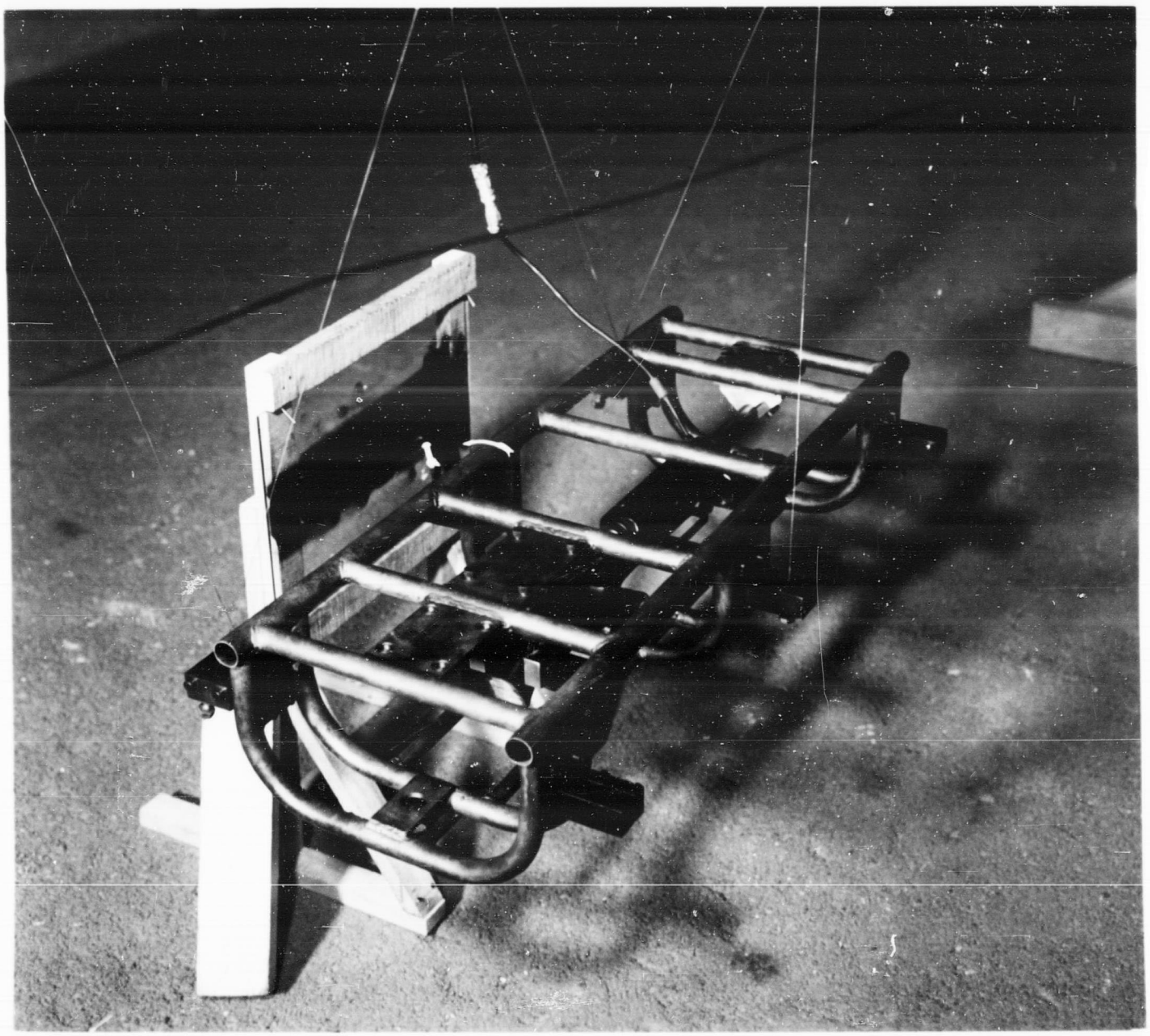
A90839 CONFIDENTIAL ABERDEEN PROVING GROUND 6 July 1953

Project No. TS1-2. Test of .224 Carbine Ammunition.
Illustrating penetration performance of Ctg., A.P., Cal. .30 Carbine, Lot No. FA-X30-1131, and Ctg., A.P., Cal. .224 (experimental), no lot, against ¼-inch homogeneous armor plate (Brinell Hardness 375) at a range of 50 yards. Numbers 1 through 6, Cal. .224. Numbers 7 through 11, Cal. .30 Carbine.



A90925 CONFIDENTIAL § ABERDEEN PROVING GROUND § 6 July 1953

Project No. TS1-2. Test of .224 Carbine Ammunition.
Illustrating recoil pendulum, with Caliber .30 Carbine and compensator in place for firing.



A90926 CONFIDENTIAL § ABERDEEN PROVING GROUND § 6 July 1953

Project No. TS1-2. Test of .224 Carbine Ammunition.
Illustrating recoil pendulum, with Caliber .30 Carbine and compensator in place for firing. Arrow shows stylus used to measure displacement on smoked glass plate.

A91616 CONFIDENTIAL § ABERDEEN PROVING GROUND § 13 August 1953

Project No. TS1-2. Test of .224 Carbine Ammunition and Weapon. TOP: Carbine, Caliber .30, M2, W/Compensator. CENTER: Carbine, Caliber .22, M2, W/Compensator. BOTTOM: Special bipod for use with above weapons.

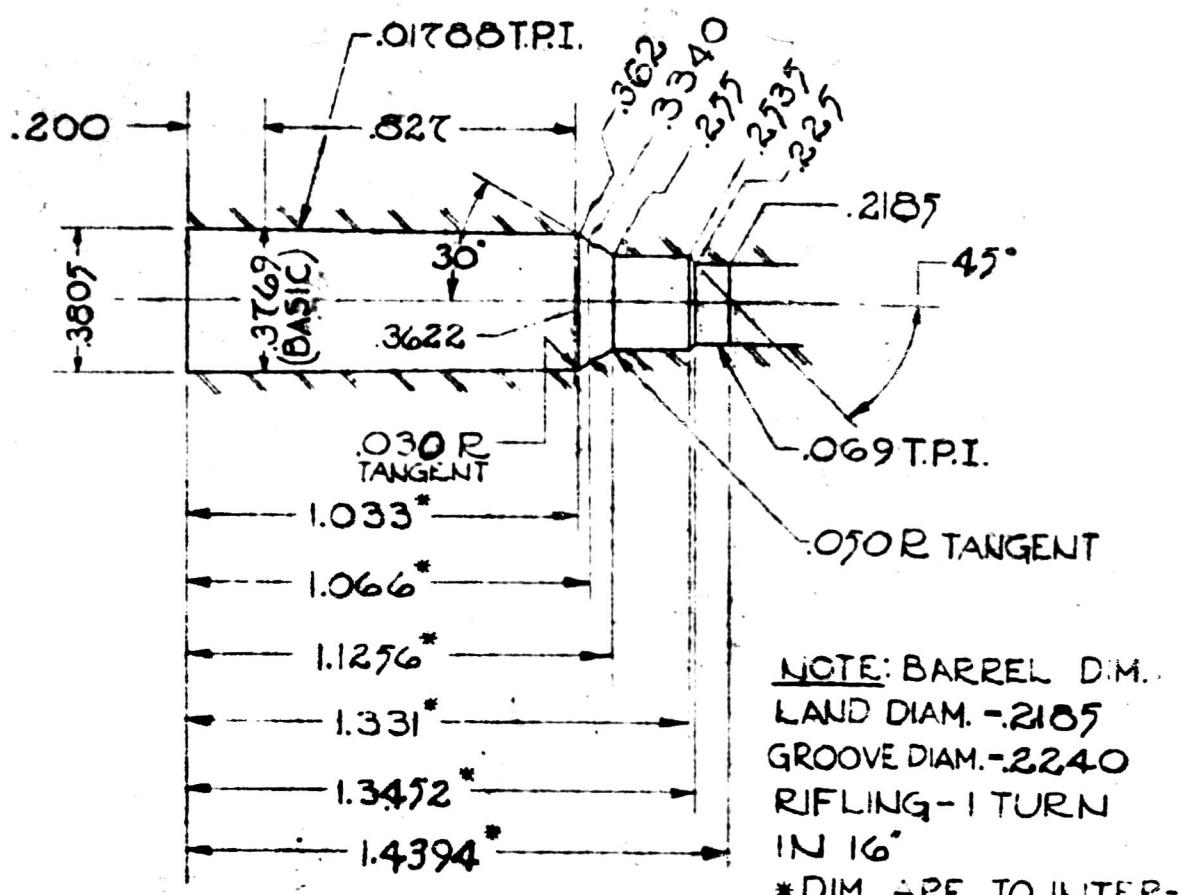
Security Information - CONFIDENTIAL

A91617 CONFIDENTIAL ABERDEEN PROVING GROUND 13 August 1953

Project No. TS1-2. Test of .224 Carbine Ammunition and Weapon. LEFT: Cartridge, Ball, Caliber .30, Carbine, M1. CENTER: Cartridge, Ball, Caliber .22 Carbine. RIGHT: Cartridge, Ball, Caliber .45, M1911.

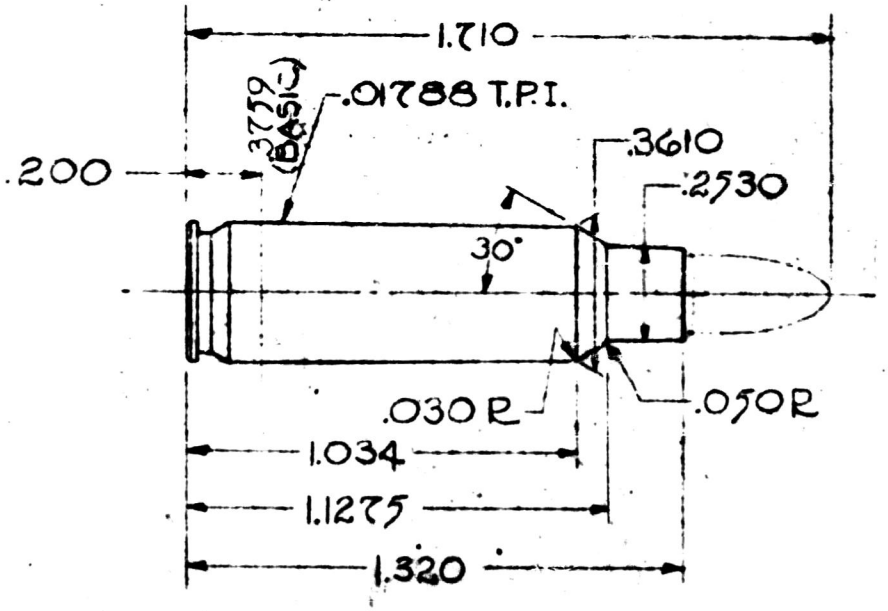
APPENDIX D

Sketch Dated 13 November 1952



MINIMUM CHAMBER

NOTE: BARREL D.M.
LAND DIAM. -.2185
GROOVE DIAM. -.2240
RIFLING - 1 TURN IN 16"
* DIM. ARE TO INTERSECTIONS OF LINES



MAXIMUM CARTRIDGE
(FROM SHORTENED .222 REMINGTON)

CHAMBER & CARTRIDGE CASE
FOR CALIBER 22 CARBINE

13, NOV. 52